COURSE MANUAL

Course Title: Production Technology of Fruit and Plantation Crops

Credit Hours: 1+1

Submitted By

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Lecture 1: IMPORTANCE OF HORTICULTURE

The horticulture sector contributes about 30.4 per cent of the agriculture GDP, besides providing employment for 19 per cent of the labour force. The demand for horticulture produce is expected to increase owing to increasing urbanization, income-lead higher standard of living, enhanced awareness of nutrition security and family welfare programmes.

A. IMPORTANCE OF HORTICULTURAL CROPS IN HUMAN NUTRITION

From human nutrition point of view horticulture is most important to our daily living. Many of the horticulture crops and their products find place in our meals and diet. Human body requires vitamins, minerals, proteins, energy etc. for its health. All these are supplied by horticultural crops. Fruits and vegetables are the chief sources of vitamins, minerals, carbohydrates, fats, proteins etc. Fruits and vegetables are recognized as protective foods as they are necessary for the maintenance of human health.

The Role of Horticulture in Alleviating Nutritional Deficiencies in the Developing World

Malnutrition is the condition that occurs when your body does not get enough nutrients.

Fruits: The Simple Solution

Vitamins: These are the important constituents of fruits and are indispensable part of human diet. Although required in very minute quantities, they are absolutely essential for the maintenance of health. The deficiency of any vitamin from the diet for considerable period may lead to diseased state or disorder conditions. Fruits supply several vitamins

- **Vitamin-A:** Sources-Mango, Papaya, Dates, Jackfruit, Walnut etc.
- **Vitamin B1 (Thiamine):**. Sources - Orange, pineapple, jack fruit, cashew nut, walnut, dry apricot, almond, banana etc,.
- **Vitamin B2 (Riboflavin):** Sources - Bael, papaya, litchi, banana, apricot, pomegranate, pear etc.
- **Vitamin -C (Ascorbic Acid):** Sources - Amla, guava, ber, citrus, strawberry, pineapple etc.
- **Calcium:** Sources - Acid lime, Orange, Fig, Dried apricots, wood apple etc.
- **Iron:** Sources - Custard apple, Guava, Pineapple, Straw berry, Grape, Black currents, dried dates etc.
- **Phosphorous:** Sources - Guava, Grape, Jackfruit, Passion fruit, Orange
- **Proteins:** Sources: Fruits- Guava and Banana. Nut fruits like Walnut, Cashew nut and almond etc supplies proteins besides energy.
- **Enzymes:** Sources: Papaya-Papain and Pineapple-Bromelin.

B. COMPARISON OF HORTICULTURE WITH OTHER AGRICULTURAL SECTORS

1. Per Unit Area Yield is High: As compared to the field crops per hectare yield of horticulture crops is very high. From an fruit area of land more yield is obtained e.g. paddy gives a maximum yield of only 30 q/ha, while Banana gives 300 to 500 q/ha, Pine apple 450 q/ha and Grapes 90 - 150 q/ha. In present shortage of food and scarcity of land by growing fruits more food can be produced.

2. High Returns per Unit Area: From one unit area of land more income will be obtained e.g. Well kept orchard of apple, grapes and sweet orange can give as much as Rs. 25,0000 per ha as net income.

3. A Free Grower/Labour Remains Engaged for the Whole: An opportunity for maintaining labours throughout the year like the cereals where one cannot keep himself and employ the labours during the slack season.

4. Best Utilization of Waste Land:

Some fruit crops can offer best utilization of waste land crops like wood apple, custard apple, karonda, litchi etc. can be grown in such areas.

5.Food energy: To meet the annual calories requirements of food per year one would have to cultivate about 0.44 ha of wheat or 0.03 ha of banana or 0.06 ha of mango for satisfying once need. Thus mango produces about 9 times more food energy than the wheat produced per unit area.

6. Raw Material for Industries: Fruit farming is the base for several industries like canning, essential oils etc which in turn provide work for more people.

7. Use of Undulating Lands: Fruit growing can be practiced in places where the gradient is uneven or where the land is undulating and agronomical crops cannot be cultivated. In Konkan region, mango and cashew are cultivated on large scales on hilly and hill back area.

C. HORTICULTURE IS ALSO IMPORTANT FOR 3 REASONS

- Economic
- Aesthetic
- Environment

a. Economic Importance

Horticulture puts over billions of rupees in a year into the Indian economy by

- Providing jobs.
- Producing food.
- Fruits.
- Vegetables.
- Nuts.
- Increasing home value through landscaping

b. Aesthetic Importance

- Aesthetic = Appearance
- Improves appearance of homes & buildings through landscaping.
- Improves appearance of land from fruit, vegetable, and ornamental crops grown

c. Environmental Appearance

- Provides health & comfort by
- Cleaning the air.
- Preventing erosion.
- Providing shade.
- Providing nutrition.

IMPORTANCE OF PLANTATION CROPS

The term Plantation crops refers to those crops which are cultivated on an extensive scale in a large contiguous area, owned and managed by an Individual or a company. The crops include tea, coffee, rubber, cocoa, coconut, arecanut, oil palm, palmyrah, cashew, cinchona etc. These plantation crops are high value commercial crops of greater economic importance and play a vital role in our Indian economy. The main draw back with this sector: of crops in India is that major portion of the area is of small holdings (except Tea) which hinders the adoption of intensive cultivation. In the case of coffee 97.13 per cent of the growers have holdings below ten hectares and in Rubber, 82 per cent of the total area is of small hojdings having an average size of 0.5 ha.

The Economic Importance of these Crops are:

1. They contribute to national economy by way of export earnings. These crops occupy less than 2 per cent of the total cultivated area (i.e. 3.82 per cent of total crop land) but they generate an income of around Rs. 16,000 million or about 12.72 per cent of the total export earnings of ail commodities or 75 per cent of total earnings from the export of agricultural produces.

2. India is the leading country in the total production of certain plantation crops in the world. For instance, our production meets the share of 47 per cent in tea and 66 per cent in each of cashew and arecanut,

3. Plantation industry provides direct as well as indirect employment lo many millions of people. For instance, tea industry offers direct employment to 10 lakhs and indirect employment to 10 lakh people, while-cashew processing factories alone provide employment to 3 lakhs people besides 2 lakhs farmers are employed in cashew cultivation.

4. Plantation industry supports many by-product industries and also many rural industries. For example, coconut husk is used to produce coir fiber annually to a tune of 2,19,600 tones in India.

5. These crops help to conserve the soil and ecosystem. Tea planted in hill slopes and cashew in barrel and waste lands protect the land from soil erosion during the rainy season or due to heavy winds.

Lecture 2: MANGO

Botanical Name: *Mangifera Indica* L.

Family: Anacardiaceae

Origin: Indo-Burma

Type of fruit Drupe

Edible part: Mesocarp

Inflorescence: Panicle

Chromosome no.: X=10, 2n=40

PRODUCTION TECHNOLOGY

Agro-climatic requirements

Although, it is a tropical fruit, the mango equally grows well in frost free subtropical region. It thrives well in almost all the regions of the country but cannot be grown commercially in areas above 600 m. However it can grow from sea level to an altitude of about 1000 meters provided; there is no high humidity, rain or frost during the flowering period It cannot stand severe frost, especially when the tree is young. High temperature by itself is not so injurious to mango, but in combination with low humidity and high winds, it affects the tree adversely.

Mango varieties usually thrive well in places with rainfall in the range of 75-375 cm. /annum and dry season. The distribution of rainfall is more important than its amount. Dry weather before blossoming is conducive to profuse flowering. Rain during flowering is detrimental to the crop as it interferes with pollination. However, rain during fruit development is good but heavy rains cause damage to ripening fruits. Strong winds and cyclones during fruiting season can play havoc as they cause excessive fruit drop.

Loamy, alluvial, well drained, aerated and deep soils rich in organic matter with a pH range of 5.5 to 7.5 are ideal for mango cultivation.

Floral biology and pollination

The mango inflorescence is primarily terminal, although axillary and multiple panicles may also arise from axillary buds. Both perfect (hermaphrodite) and staminate (male) flowers occur in the same inflorescence. The total number of flowers in a panicle may vary from 1000 to 6000, depending on the cultivar. There is heavy drop of hermaphrodite flowers upto 99% only 0.1 % or less hermaphrodite flowers develop fruit to maturity.

Varieties Cultivated

In India, about 1,500 varieties of mango are grown including 1,000 commercial varieties. Each of the main varieties of mango has an unique taste and flavour.
Based on time of ripening, varieties may be classified as under :

Early	-	Bombai, Bombay Green , Himsagar, Kesar, Suvernarekha
Mid-season	-	Alphonso, Mankurad, Bangalora, Vanraj, Banganapalli, Dashehari, Langra, Kishen Bhog, Zardalu, Mankurad
Late	-	Fazli, Fernandin, Mulgoa, Neelum, Chausa

Hybrids:
Amrapalli (Dashehari x Neelum), Mallika (Neelum x Dashehari), Arka Aruna (Banganapalli x Alphonso), Arka Puneet (Alphonso x Janardhan Pasand), Arka Neelkiran (Alpohonso x Neelum), Ratna (Neelum x Alphonso), Sindhu (Ratna x Alphonso), Au Rumani (Rumani x Mulgoa), Manjeera (Rumani x Neelum), PKM 1 (Chinnasuvernarekha x Neelum), Alfazli, Sunder Langra, Sabri, Jawahar, Neelphonso, Neeleshan, Neeleshwari, PKM 2 (very few of these hybrid varieties are grown commercially in the country).

The important mango varieties cultivated in different states of India are given below :

State		**Varieties grown**
Andhra Pradesh	-	Allumpur Baneshan, Banganapalli, Bangalora, Cherukurasam, Himayuddin, Suvernarekha, Neelum, Totapuri
Bihar	-	Bathua, Bombai, Himsagar, Kishen Bhog, Sukul, Gulab Khas, Zardalu, Langra, Chausa, Dashehari, Fazli
Goa	-	Fernandin, Mankurad
Gujarat	-	Alphonso, Kesar, Rajapuri, Vanraj, Jamadar, Totapuri, Neelum, Dashehari, Langra
Haryana	-	Dashehari, Langra, Sarauli, Chausa, Fazli
Himachal Pradesh	-	Chausa, Dashehari, Langra
Jharkhand	-	Jardalu, Amrapalli, Mallika, Bombai, Langra, Himsagar, Chausa, Gulabkhas
Karnataka	-	Alphonso, Bangalora, Mulgoa, Neelum, Pairi, Baganapalli, Totapuri
Kerala	-	Mundappa, Olour, Pairi
Madhya Pradesh	-	Alphonso, Bombay Green, Langra, Sunderja, Dashehari, Fazli, Neelum, Amrapalli, Mallika
Maharashtra	-	Alphonso, Mankurad, Mulgoa, Pairi, Rajapuri, Kesar, Gulabi, Vanraj
Orissa	-	Baneshan, Langra, Neelum, Suvarnarekha, Amrapalli, Mallika
Punjab	-	Dashehari, Langra, Chausa, Malda
Rajasthan	-	Bombay Green, Chausa, Dashehari, Langra
Tamil Nadu	-	Banganapalli, Bangalora, Neelum, Rumani, Mulgoa, Alphonso, Totapuri
Uttar Pradesh	-	Bombay Green, Dashehari, Langra, Safeda Lucknow, Chausa, Fazli
West Bengal	-	Bombai, Himsagar, Kishen Bhog, Langra, Fazli, Gulabkhas, Amrapalli, Mallika

- Sindhu is a seedless variety of mango.
- Coloured mango cultivars Tommy Atkins, Zilette, Haden, Sensation Julie, Vanraj, Husn-e-ara and Sensation
- Mulgoa is the mother of all Floidan coloured mango cultivars
- Besides Alphanso, Kesar, Gulabkhas, Safdar Pasand and Lakhan Bhog are mango cultivars suitable for export
- Amarapali and Arka Aruna are dwarf mango cultivars

Polyembryonic varieties of India: Bappakai, Chandrakaran, Bellary, Goa, Kurukkan, Nileswar dwarf. Olour, Pahutan, Salem, Mazagoaon, Mylepalium and vellaikolumban. These are common in west coast i.e., Malabar region in west coast.
Polyembryonic varieties introduced from other countries in to India: Apricot, Simmonds, Higgins, Pico, Sabre, Saigon, Strawberry, Cambodiana, Turpentine and Carabao.

ROOTSTOCKS:

- Vellaicollamban is the only octaploid (2n=8x=80) variety and is a potential polyploidy dwarfing rootstock of mango
- Kurrukan is a polyembryonic salt resistant rootstock of mango
- Moovandan and Nekkare are also salt tolerant mango rootstocks\
- Rumani is a dwarfing rootstock in mango

Planting

Planting Material

Mango can be propagated from seed or propagated vegetatively. Plants are generally propagated vegetatively by using several techniques like veneer grafting, inarching and epicotyl grafting etc.

Planting Season

Planting is usually done in the month of July-August in rainfed areas and during February-March in irrigated areas. In case of heavy rainfall zones, planting is taken up at the end of rainy season.

Spacing

The planting distance is 10m. x 10m. and 12m. x 12m. in dry and moist zones respectively. In the model scheme, a spacing of 8m. x 8m. with a population of 63 plants per acre has been considered which was observed to be common in areas covered during a field study. In HDP Amrapalli is being planted at 2.5. x 2.5m.

Training of Plants

Training of plants in the initial stages of growth is very important to give them a proper shape especially in cases where the graft has branched too low. In HDP open centre system is highly successful.

Nutrition

Fertilizers may be applied in two split doses , one half immediately after the harvesting of fruits in June/July and the other half in October, in both young and old orchards followed by irrigation if there are no rains. Foliar application of 3 % urea in sandy soils is recommended before flowering.

The following table gives the details of fertilizer applied (depending upon the age of the plants) :

Age of the plant (in years)	Fertilizer applied
1*	100g. N, 50g. P_2O_5, 100g. K_2O
10	1kg. N, 500g. P_2O_5, 1kg. K_2O
11	-do-

**The doses applied in the subsequent years should be increased every year upto 10 years in the multiple of the first year's dose*.

Well decomposed farm-yard manure may be applied every year. For trench application of fertilizers, 400g. each of N and K_2O and 200g. of P_2O_5 per plant should be provided. Micro-nutrients may be applied as per the requirement in the form of foliar sprays.

Irrigation

The frequency and amount of irrigation to be provided depends on the type of soil, prevailing climatic conditions, rainfall and its distribution and lastly the age of the trees. No irrigation is required during the monsoon months unless there are long spells of drought.

Age of the plant (in years)/Growth stage	Irrigation schedule
1	• Irrigated at an interval of 2-3 days during dry season.

2-5	• Irrigation interval- 4-5 days.
5-8/ fruit set to maturity	• Irrigated after every 10-15 days
Full bearing stage	• 2-3 irrigations after fruit set.

Frequent irrigation during 2-3 months prior to the flowering season is not advisable as it is likely to promote vegetative growth at the expense of flowering. Irrigation should be given at 50% field capacity. Generally inter-crops are grown during the early years of plantation and hence frequency and method of irrigation has to be adjusted accordingly. The method usually followed for irrigating mango plants is basin irrigation. However, use of Drip Irrigation will not only reduce the water requirements but will also help in fertigation in root zones of the plants.

Intercultural Operations

The frequency and the time of inter-culture operations vary with age of the orchards and existence of inter-crops. The weed problem may not exist immediately after planting the mango crop but it is advisable to break the crust with hand hoe each time after 10-15 irrigations are applied. In case of mono-cropping, the area between the basins should be ploughed at least three times in a year i.e. during the pre-monsoon, post-monsoon period and in the last week of November.

Inter-cropping

Intercropping can be taken up till the mango trees attain suitable height and develop canopy (at 5-6 years of age).Leguminous crops like green gram, black gram, gram etc., cereals like wheat, oilseeds like mustard, sesame and groundnut, vegetable crops such as cabbage, cauliflower, tomato, potato, brinjal, cucumber, pumpkin, bitter gourd, tinda, lady's finger etc. and spices like chillies can be grown as intercrops. The partial shade loving crops like pineapple, ginger, turmeric etc. can be cultivated in fully grown orchards. In addition to field crops, some short duration , less exhaustive and dwarf type inter-fillers like papaya, guava, peach, plum etc. can be grown till these do not interfere with the main mango crop .It is advisable to take vegetable crops as inter crops for better returns.

The average cost of inter cropping would be Rs.10,000 / Acre and it would yield on an average of 6 tonnes / Acres.

Crop Management

Regulation of Bearing

Proper cultural practices like addition of fertilizers and control of diseases and insect pests may be adopted to regulate growth and bearing. Regular bearing varieties viz. Dashehari and Amrapalli may be grown. Deblossoming of the panicles with NAA @ 200 ppm. (20 g./100 l. water) during 'on' year may help to regulate the bearing.

Regulation of Fruit Drop

Embryo abortion, climatic factors , disturbed water relation, lack of nutrition, attack of disease and pest, hormonal imbalances are the major factors that lead to fruit drop. A spray of Alar (B-Nine) @ 100 ppm. or 20 ppm. 2,4-D (2g. in 100 l. water) in the last week of April or in the last week of May will control to some extent the summer fruit drop in Langra & Dashehari.

Plant Protection Measures

Insect Pests

Insect pests mostly observed are mealy bug, hopper, inflorescence midge, fruit fly and scale insects. For controlling these insects, spraying with carbaryl, monocrotophos, phosphamidon & methyl parathion are recommended.

Harvesting and Yield

The orchard starts bearing from sixth year onwards and the economic life of a mango tree exceeds 40 years. A full bearing mango tree having an age of more than 15 years bears about **1000-3000** fruits during **on** year.

Yield of fruits varies considerably according to the variety, climatic conditions, plant population etc. On an average the productivity of mango in India is 6.6 MT/HA (NHB-2010-11). Grafted plants start bearing early.

Lecture 3: Mango Disorders

Spongy Tissue:

A non edible sour patch developed in the mesocarp of mango fruit is broadly termed *spongy tissue*. The malady has been reported only in Alphonso. The peculiarity of this malady is that external symptoms of the fruit affected by spongy tissue are not apparent at the time of picking or at the ripe stage. These can be detected only on cutting the ripe fruit. This malady renders the fruit unfit for human consumption. It is a physiological disorder in which fruit pulp remains unripe because of unhydrolyzed starch due to physiological and biochemical disturbances caused by heat in mature fruit at pre-and post-harvest stages. Single and double preharvest dip of fruits in calcium solution significantly increased the calcium content in the ripe fruits, whereas there was no significant increase in calcium content by post harvest Ca dip treatment.

The pre harvest dip significantly reduced the occurrence of spongy tissue in the ripe 'Alphonso' fruits. The use of wind-breaks for protecting the orchard from warm air during May, and use of proper precautions at post-harvest stage checks the disorder. Use of mulching and post harvest exposure to low temperatures between 10-15 C for 10-18 hours has been useful in reducing the malady.

Mango Malformation:

Malformation is widely prevalent in northern India, particularly in the states of Punjab, Delhi and

western U.P. where more than 50% of the trees suffer from this malady. The malformed panicles remain unproductive and are characterized by a compact mass of male flowers, greenish in colour and stunted in growth. The main and secondary rachis is thick and short and bears flowers with relatively larger bracts, sepals and petals as compared to normal flowers. The malformed panicles remain intact on the trees for a considerable long period. The complexity of the disorder is attributed to cultural, nutritional and factors like, mites, fungal, viral, hormonal imbalance etc. The exact cause and control of the malady is yet to be established.

Control: Spraying of Planofix (200 ppm) during the first week of October followed by deblossoming at bud burst stage is recommended as a remedial measure against malformation.

Malformation

Among all the known diseases and insect pests of mango, malformation is undoubtedly the most serious. Depending on the plant part affected, two categories of the malformation,vegetative and floral, have been recognized. In vegetative malformation, the vegetative buds in the leaf axils or at the apical meristem of the younger plants, on activation, develop abnormally as compact rosette-like shootlets, bearing tiny leaf rudiments. Many such shoots may arise to form a bunch, hence it is also sometimes known as bunchy top. The problem is not serious in the grown-up trees. The affected new shoots on the old trees, however, become thick, stunted, and develop a whorl of small leaves. Floral malformation, in contrast, is very virulent and can cause the loss of the entire crop. It affects the fruit production directly by converting the panicle to a barren one. Floral malformation exhibits all sorts of symptoms, but any deviation of a part of the panicle, or all the parts of a panicle, from the normal to abnormal should be considered as a symptom of this malady. In severe form, the affected panicle appears like a compact mass, being more green and sturdy. It bends down due to its own weight.

It is found that the application of 200ppm NAA during the first week of October as spray resulted in considerable reduction of floral malformation. Early deblossoming, combined with NAA spray during October, may reduce the extent of malformation considerably.

Biennial Bearing:

The term biennial, alternate or irregular bearing generally signifies the tendency of mango trees to bear a heavy crop in one year (On year) and very little or no crop in the succeeding year (Off year). Most of the commercial varieties of north India, namely, Dashehari, Langra and Chausa are biennial bearers, while south Indian varieties like Totapuri Red Small, Bangalora, and Neelum are known to be regular bearers. When a tree produces heavy crop in one season, it gets exhausted nutritionally and is unable to put forth new flush thereby failing to yield in the following season. The problem has been attributed to the causes like genetical, physiological, environmental and nutritional factors.

Control: For overcoming biennial bearing, deblossoming is recommended to reduce the crop load in the 'On' year so that it is balanced in the 'Off year. Proper maintenance of orchard by way of effective control of pests and diseases and regular cultural operations may also result in better performance of the tree every year. Soil application of Paclobutrazol (PP) or Cultar @ 4 g/tree in the month of September resulted in 333 early flowering with higher fruit set and yield. It may be applied every year for regular fruiting, particularly in young trees.

Ringing of branches is recommended as means of inducing flowering in the 'Off' year. However, Weak, stunted, unhealthy trees should not be ringed to force flowering. It involves removal of 1 cm wide ring of bark on a branch of about 15 cm thickness. Ringing stops vegetative growth and results in accumulation of carbohydrates and other metabolites in the portion of the branch above the ring, thereby creating physiological condition for flowering. Ringing should be done in August or early September, well before the time of fruit-bud differentiation.

Fruit Drop:

The intensity of fruit drop varies from variety to variety. Among the commercially grown varieties, Langra is more susceptible to drop, while Dasheri is the least. The fruit drop is more or less a continuous process and can be classified into three phases, viz. (i) pinhead drop, (ii) post-setting drop and (iii) May-month drop. The fruit drop in first two phases are insignificant compared to the third phase which affects the final yield significantly and needs more attention. Embryo abortion, climatic factors, disturbed water relation, lack of nutrition, attack of disease and pest and hormonal imbalances are the major factors that lead to fruit drop.

Control: The foliar application of Alar (B-nine) @ 100 ppm or NAA 20 ppm at pea stage of fruit was found effective in controlling fruit drop in mango.

Black Tip:

Black tip is a serious disorder, particularly in the cultivar Dasheri. The affected fruits become unmarketable and reduce the yield to a considerable extent. The damage to the fruit gets initiated right at marble stage with a characteristic yellowing of tissues at distal end. Gradually, the colour intensifies into brown and finally black. At this stage, further growth and development of the fruit is retarded and black ring at the tip extends towards the upper part of the fruit. Black tip disorder has generally been detected in orchards located in the vicinity of

brick kilns. It has been reported that the gases like carbon monoxide, sulphur dioxide and ethylene constituting the fumes of brick kiln are known to damage growing tip of fruits and give rise to the symptoms of black tip. Apart from these factors, irrigation, condition of the tree and management practices also play important role in deciding the severity of the disorder.

Control: Planting of mango orchards in North-South direction and 5-6 km away from the brick kilns may reduce incidence of black tip to a greater extent. The incidence of black tip can also be minimized by spraying Borax (1%) or other alkaline solutions like caustic soda (0.8%) or washing soda (0.5%). The first spray of Borax should be done positively at pea stage followed by two more sprays at 15 days interval.

Clustering in Mango ('Jhumka') :

A fruiting disorder, locally known as 'Jhumka', is characterised by the development of fruitlets in

clusters at the tip of panicles. Such fruits cease to grow beyond pea or marble stage and drop downafter a month of fruit set. Absence of sufficient population of pollinators in the orchards is the majorreason. The other reasons causing the disorder are old and overcrowding of trees, indiscriminate spraying against pests and diseases, use of synthetic pyrethroids, monoculture of Dashehari and bad weather during flowering.

Control : Introduction of beehives in the orchards during flowering season for increasing the number of pollinators and restrict insecticidal sprays at full bloom to avoid killing of pollinators. Pests and diseases should be controlled in time by spraying the recommended pesticides and concentrations. Spraying of NAA (300 ppm) during October-November is recommended. The practice of monoculture of a particular variety may be avoided. Particularly in case of Dashehari, 5- 6% of other varieties should be planted in new plantations.

Lecture 4: BANANA (*Musa* spp.)

Family: Musaceae; **2n= 3x= 33**

Origin: South East Asia

Popularly known as Tree of Paradise/ Tree of Wisdom

Area:803000 ha ; Production: 29725 000 MT: ; Productivity: 37 t/ha

Major producing state: Tamil Nadu, Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Bihar, Assam and Madhya Pradesh

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Area:TN>Karnataka>AndhraPradesh

Production:TN>Maharashtra>Gujarat

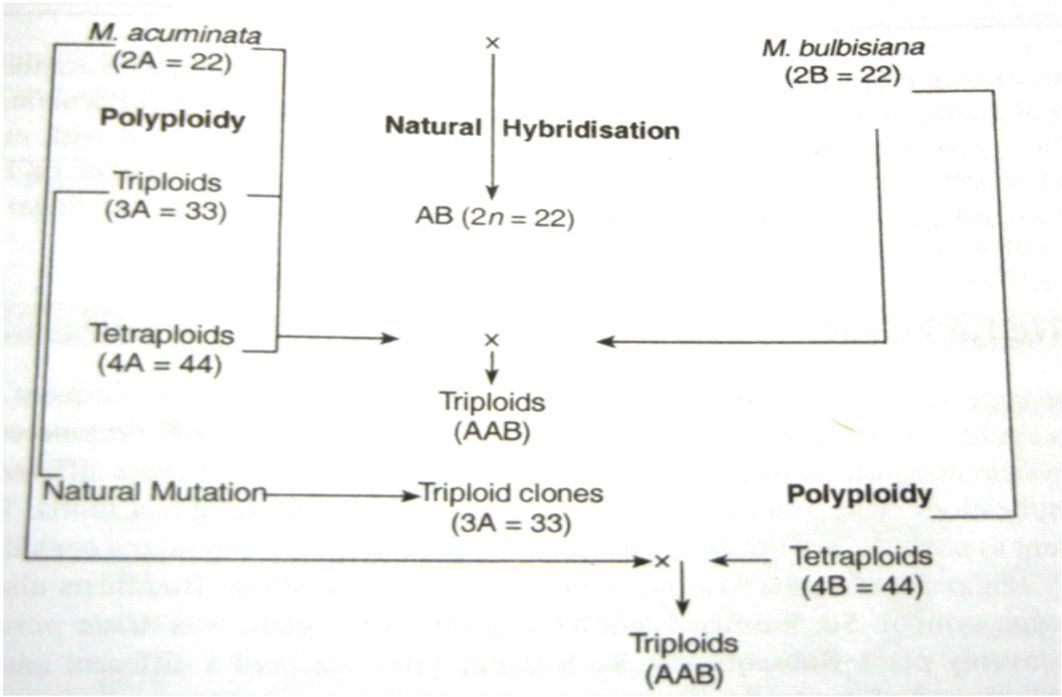
Productivity: Madhya Pradesh > Gujarat > Maharashtra

Nutritional properties: Water 61-78% and Carbohydrate- 20-25%. P- 290 ppm, Ca- 80 ppm and Fe- 6 ppm

Uses:

1. Table fruit as well as vegetables
2. Processed product- flecks, powder, banana figs, banana chips
3. Add pleasant flavour in ice cream
4. leaves and pseudostem- good feed for animals
5. Male flower and pseudostem- used as vegetables
6. Sheath- good source of fibre
7. Leaves- used as biological plate to serve food and also used as wrapping material
8. Ornamental plants- *M. ornata, M. velutina, M. flaviflora*

Origin of cultivated forms



Scoring technique of banana:

Simmonds and Shepherd (1955) devised scoring technique in banana for distinguishing *M. acuminata* type from *M. balbisiana* by using 15 morphological characters. For each characters, cultivar agreed with *M. acuminate*, given a score of one (1) and for *M. balbisiana*, a score of five (5) while for intermediate expression, score of 2, 3 and 4 will be given according to the intensity of the characters. Hence, the total score ranged from 15 (pure *M. acuminata*) to 75 (pure *M. balbisiana*). Score in between 15-75 would be based on relative genomic constitution of the two spp. They classify the whole edible banana into 6 genomic groups- AA, AAA, AAB, AB, ABB and ABBB. But they did not mention BB/BBB in their classification. Later on Silayoi and Chamchalow (1987) introduced BB/BBB in banana genomic group by modifying the classification of Simmond and Shepherd (1955).

The details taxonomic classification of banana and scores is as follows-

Genomic constitution	Ploidy level	Score	
		Simmond and Shepherd	Silayoi and Chamchalow
AA	2X	15-23	15-25
AAA	3X	15-23	15-25
AAB	3X	24-46	26-46
AB	2X	49	-
ABB	3X	59-63	59-63
ABBB	4X	67	67-69
BB/BBB	2X/3X	-	70-75

Varieties:

AA

- **Lady's Finger:** Fruit is sweet in taste with thin skinned.

AAA

- **Gross Michel:** Occupy about 63% of world trade
- **Dwarf Cavendish (Basrai, Singapuri):** Leading commercial cultivar of India, contributing about 58% of total production owing to its high yield, ability to withstand strong wind and give high economic return/unit area
- **Robusta (Harichal, Bombay Green):** Semi-tall sport of Dwarf Cavendish. Plant completes its life cycle within one year.
- **Giant Cavendish (Grand Naine, Giant Governor):** Tall mutant of Dwarf Cavendish.
- **Red Banana:** Having red pigments in leaf, petiole, sheath and fruit.
- **Amritsagar**
- **Chakkarakeli**

AAAA

- **Bodley Altafort: Gross Michel × Pisang Lilin**

AB

- **Ney Poovan**
- **Kunnan** (most suitable for processing like banana fig, powder)

AAB

- **Rasthali** (Morthoman, Malbhog)
- **Poovan** (Champa, Chini Champa)
- **Nendran** (Plantain): Duel purpose variety (table and cooking). Used for processing-powder, chips, fig
- **Hill Banana** (Virupakshi, Ladan): Grow at higher elevation under rain fed condition
- **Rajapuri**

ABB (Cooking banana)

- **Monthan** (Bontha): most suitable for making chips
- **Karpuravalli** (Sail Kola): Hardy crop, can tolerate drought, salt and wind.
- **Klue Teparod**

Promising Hybrids

- **H1(AAB):** Agniswar x Pisang Lilin
- **H2 (AAB):** Vennan x Pisang Lilin
- **CO1 (AAB):** Kallar Ladan x Sawai x Kadali.
- **FHIA 1(AAAB):** Also known as Gold Finger
  FHIA 2, FHIA 3 etc

Soil: Banana can grow in all kind of soil starting from clay to sandy, acidic to alkaline. However, clay soil with moderate water holding capacity and adequate drainage is optimum for banana cultivation. Similarly, sandy loam soil with proper irrigation facility may also be selected for successful banana cultivation. The pH of 6.5- 7.5 is optimum but can also grow in soil having pH up to 8.5.

Climate: It is a crop of tropics to humid subtropics to semi-arid subtropics up to 2000 m msl. It can grow in a wide range of temperature - 15-35°C with optimum range of 20-30°C with an annual rainfall of 50-200 cm/annum (100-125 cm opt.). Low temperature (below 10°C) at bunch emergence stage prevents the growth of rachis and inflorescence start to come out from pseudostem directly causing 'Chok Throat' disorder. However, temperature above 36-38°C causes scorching effect on the tree.

Propagation:

1. Suckers:

Water sucker- Developed from shallow buds near the soil surface, having broad leaves

Sword sucker- Originated from axilary bud lower down on the parent rhizome, having small, thin and sword shaped leaves – used for commercial multiplication (weight- 500-700 g)

2. Micro-propagation by shoot tip culture is also commercialized for rapid multiplication of banana

Planting season: Warm and humid condition is pre-requisite at the time of planting- rainy season (July-September) is best time for planting of banana.

Spacing:

- Tall cultivars- 2.4 x 2.4 m (Grand Naine)
- Semi tall- 2.1 x 2.1 m (Poovan, Rasthali, Nendran, Robusta)
  Dwarf- 1.8x 1.8 m (Dwarf Cavendish)

Method of planting: For planting of banana 1st pit should be prepared at a size of 60x60x60 cm. after digging the pit, it should be filled with soil, sand and FYM mixture @ 1:1:1 ratio. Thereafter, Planting of sucker should be done at the centre of pit at a depth of 30-40 cm. Apart from this pit system of planting, Furrow system of planting is practiced in Maharastra and Gujarat at 30-40 cm depth.

Manuring and fertilization: Banana is a heavy feeder crop; require large quantity of nutrients accounting 20-30% of total cost of production. For better growth and yield, FYM should be applied @ 10kg/plant at the time of planting. Each plant required a total of 100-250 g nitrogen. Among which 50 g should be applied at the time of planting and 150 gm at vegetative stage (50 g/split) while remaining 50 g at reproductive stage of the plant. However, phosphorous should be applied only at the time of planting @ 20-40 g/plant. Banana is a heavy feeder of potash. It needs 100 g/plant (2 split) of K at vegetative stage and 100 g/plant (2 split) in reproductive stage. Apart from these, Ca, Mg, Fe, Zn, Mn should be applied @ 0.005-0.1% each.

Water management: AAA and AAB clones of banana can be grown under irrigated condition while ABB under rain fed condition. Irrigation at 5-15 days interval depending upon the available moisture in soil with a total of 100-125 cm in 18 months is the pre-requisite for better growth and development of banana plants. Normally furrow and basin and trench systems are followed. The furrow or basin system is useful if water availability is not a constraint. Trench method is followed especially in wetland system of cultivation. However, Drip irrigation system gained popularity in banana and it is most suitable for plain and undulated land and also most economic as it not only save 40-50% water but early harvest is also achieved with higher yield/unit area.

Weed management:"Weed reduce yield upto 40-50% depending upon the cultivar and soil. 1st six months of growth are most critical for weed growth. The plantation have to be kept completely weed free during that time. Hence, regular hand weeding is essential. In wetland cultivation, turning the top soil to bury the weeds after complete wetting the field followed by no irrigation for 15-20 days is commonly practiced to check the weed growth for 2-3 months. Apart from cultural practices, chewmical control using 0.4% glycel spray is also effective. But an integrated weed management by intercropping with cowpea, soil mulching with sugarcane trash and paddy straw and one spray of glycel is economical.

Aftercare:

- **Desuckering:** It is the removal of surplus and unwanted suckers from the mother plant. It should be done once in 45 days. In young plantation (upto 2-3 months), heading back of

suckers with a sharp knife is commonly practiced. However, in old plantation, removal of suckers along with their rhizome is followed.

- **Intercropping:** It is a common practice in banana orchards to check weed growth, improve soil health and to augment some additional income. In initial years, cowpea, soyabean, beans, turmeric, ginger, onion are grown as intercrop. Intercropping with brinjal and cucurbits should be avoided as they can cause the attack of nematodes or soil borne diseases in banana plantation.
- **Mulching:** Mulching helps to conserve soil moisture and suppress weed growth. Organic mulching also helps to improves soil health. Sugarcane trash @ 10 t/ha provides effective mulching for conservation of moisture. Paddy straw, dried leaves of *Pongamia* and polyethylene sheet can also be used effectively as mulching materials in banana field.
- **Removal of dried leaves:** As the young plants grow and lower leaves start to dry, they are separated from the pseudostem and fall apart. To avoid weakening of the pseudostem, it is a common practice to tie all the leaf sheaths with a dried banana leaf. This operation is done periodically at bimonthly interval. Dried or diseased leaves also required to be removed at regular intervals for better sanitation of the plantation and to prevent pest and disease infestation and also to expose the plant to sunlight. For maximum yield, a minimum of 10-12 leaves are required to be retained on the mother plant.
- **Propping:** It is the practice of staking the plant with bamboo or *Casurina* poles immediately after bunch emergence to avoid lodging of the plant due to overload. It is essential in tall cultivars.
- **Denavelling:** It is the removal of male bud after completion of female phase. It serves the dual purpose of saving movement of food to unwanted sink and earns additional income as the male bud used as vegetable.
- **Bunch covering:** Bunch covering is practiced for Cavendish and silk group of banana. Under subtropical condition, covering or wrapping the bunche with perforated polyethelene bags increase yield by 15-20%. Covering the bunch by using dried leaves is also practiced to avoid direct exposure of peduncle to sunlight. Uncovered peduncle when exposed to sun is scorched and causes secondery infection by *Colletotrichum* resulting poor finger filling.

Harvesting: For long distance market, harvesting should be done at 75-80% maturity & for local market at full maturity.

Maturity indices:

- Number of days from flower emergence to maturity- 90-120 days.
- Disappearance of angularity
- Brittleness of floral remnants and their natural shedding
- Change of skin colour from dark green to light green or yellow
- Drying of top leaves

Yield: Avg yield 15-40 t/ha

Ratooning: Ratooning is done when $3/4^{th}$ plants in an orchard come into flowering, allow 1 sucker to grow along with mother plant. It is done by chopping the vegetative growth of sucker at 1.5-2 months stage to allow the rhizome to grow and enlarge. At the time of harvesting this sucker will get ready as ratoon crop.

Lecture 5: Citrus (*Citrus* spp.)

Family: Rutaceace; **2n= 2x= 18**

Origin: South East Asia (North-eastern India and adjacent China)

Area:1078 000 ha; Production: 11147 000 MT; Productivity: 10.3 t/ha

Citrus constitutes a major group of fruits that composed of orange, mandarin, lime, lemon, grapefruit, pummelo, tangelo, lemonime, kumquat, trifoliate orange, citron, citranges *etc*. The family Rutaceae having a large number of genus among which six genera *viz*. *Citrus*, *Poncirus*, *Fortunella*, *Microcitrus*, *Eremocitrus* and *Clymenia*) comprises the true citrus fruits. Among them, *Poncirus*, a monotypic genus, occurs naturally in Central and North China, is deciduous in nature and highly resistant to cold. However, other genera are evergreen in nature. *Fortunella* (from South China) is highly tolerant to prolonged winter. *Microcitrus* is resistant to burrowing nematode and phytophthora. *Eremocitrus* (from Australia) is highly drought resistant (xerophytic).

Uses

- Mandarin, oranges and grapefruit, pummelo used as table fruit
- Lime, lemon is popularly used in salad
- Juice of lemon and lime- sweet soft drinks, lemonades, lime cordial
- Mandarin, oranges- marmalades, mixed fruit jam, juice concentrate
- Citron peel and whole kumquat fruit- candied
- Lime and lemon- pickles and commercial citric acid
- Essential oils from flower and fruit- cosmetic industries
- Essential oils from grapefruit and lemon- insecticidal properties
- Medical properties- prevent cancer (due to antioxidant properties), heart attack (by reducing cholesterol content in the blood- resulting minimization of cholesterol clogging in arteries)

Classification: Citrus classification is quite complicated and confused because a large number of cultivars, hybrids, polyploids, mutants and polyembryonic species are exist in nature with wide variability. In addition, many local names of different cultivars, changing botanical nomenclature at different locality, unexplained relationship between different cultivars makes the task of classification more complicated. Out of these confusion, W.T. Swingle (USA) (1948) considered 16 species under the genus *Citrus* with 2 subgenera- *Eucitrus* (10 species) and *Papeda* (6 species). However, T. Tanaka (Japan) described as many as 144 species under the genus *Citrus* (1954) with two subgenera- *Archicitrus* (98 species) and *Metacitrus* (46 species).

Demerits of these 2 classifications:

Swingle's classification: Not sufficiently comprehensive. He considered most of the species as of hybrid origin and rejected those species which were not occurring in nature in wild form. He failed to cover many forms of horticultural importance and many species of Japanese, Chinese and of Indian origin.

Tanaka's classification: He considered much more comprehensive and detailed classification, contained excessive number of species, some of them being doubtful validity. In the mandarin group alone, he described 35 species, resulting in too much confusion and less practical utility.

Later on, Hodgson (1961) proposed a comprehensive classification by specifying a total of 31 species under the genus *Citrus*.He gave specific rank to Rough lemon, Sweet lime, Rangpur lime, Cleopatra mandarin and others, thus increasing the number from 16 to 31.

Different citrus groups:

1. **Mandarin group:**

- *Cirtus reticulate* (Common mandarin): Origin- China. Important cultivars- Nagpur mandarin, Coorg mandarin, Khasi mandarin, Ponkan mandarin, Darjeeling or Sikkim mandarin
- *C. unshiu* (Satsuma group): Origin- Japan. It is a cold hardy species. Important cultivars- Satsuma mandarin(from Japan), Owari, Kara, Silver Hill *etc*.
- *C. deliciosa* (Willow leaf group): Origin- Mediterranean region. Important cultivars- Willow leaf mandarin, Kinnow and Wilking (from USA), Blinda (from Algeria).
- *C. nobilis* (King group): Origin- Indo-China. Important cultivars- King (from USA).

- Kinnow- King x Willow leaf mandarin (by H.B. Frost,1935).Introduced in India (Punjab) in 1958. spreading to northern and western India at faster rate.

2. Orange group:

- *C. sinensis* (Sweet orange): Origin- China. Important cultivars- Mosambi, Malta Blood Red, Satgudi, Valencia, Pineapple, Jaffa, Hamlin, Washington Navel (From USA), Samouti (from Israel), Succari (from Egypt), Dobla Fina (from Spain) *etc*.
- *C. aurantium* (Sour orange): Cold hardy species.

3. Pummelo-grapefruit group:

- *C. grandis* (*C. maxima*) (Pummelo): Origin- Malayasia and Polynesia. It is a monoembryonic species.
- *C. paradisi* (Grapefruit): Origin- West Indies. Important cultivars- Foster, Ruby, Marsh Seedless, Duncan, Thompson, Redblush, Triumph.

4. Acid group:

- *C. limon*(lemon): Origin- East Asia. Important cultivars- Eureka and Lisbon (from USA), Femminello and Monachello (from Italy), Kaghzi Kalan, Italian Round, Assam lemon, Villafrance, Elaichi Nimbu.
- *C. jambhiri* (Rough lemon): Origin- India. Fairly tolerant to most of the virus including tristeza.
- *C. aurantifolia* (Acid lime): Origin- India. Important cultivars- Kagzi lime, Pramalini, Vikram, PKM-1, Chakradhar, Seedless lime, Selection 49
- *C. limettoides* (Sweet lime): Origin- India. Important cultivars- Sharbati (Mitha-nimbu), mithachikna, Mithotra

5. Wild and semi wild species:

- *C. indica*: Origin- India.
- *C. latipes* and *C. ichangensis*: Cold tolerant species.
- *C. assamensis* (*C. pennivesiculata* var. *assamensis*): Origin- Assam (India). Having leaf aroma similar to ginger or eucalyptus.
- *C. macroptera*

6. Related genera:

- *Poncirus*: Origin China. Having single species- *P. trifoliata*. It is deciduous species with trifoliate leaves. Plants highly thorny, fruit inedible. Resistant to different biotic and abiotic stresses.
- *Fortunella*: The fruits of this genera are mostly used for ornamental purpose.

7. Intergeneric hybrids:

- Citrange: *C. sinensis* × *P. trifoliata*.
- Citrangequat: It is a trigeneric hybrid between *Citrus*, *Poncirus* and *Fortunella*.
- Citrangedin: Citrange × Calamondin (*C. mitis*).
- Citrangor: Citrange × *C. sinensis*
- Cicitrange: Citrange × *P. trifoliate*
- Citrumelo: *C. paradise* × *P. trifoliata*
- Citrandarin: *C. reticulata* × *P. trifoliata*
- Citremon: *C. limon* × *P. trifoliata*
- Citradia: *C. aurantium* × *P. trifoliata*
- Citrumquat: *P. trifoliata* × *Fortunella*
- Limequat: *C. aurantifolia* × *Fortunella*

8. Intrageneric hybrid:

- Tangor: *C. reticulata* × *C. sinensis*.
- Tangelo: *C. reticulata* × *C. paradisi*.
- Lemonime: *C. limon* × *C. aurantifolia*
- Lemonnage: *C. limon* × *C. sinensis*
- Lemondarin: *C. limon* × *C. reticulata*

Botany: Citrus is an evergreen shrubs (upto 10 m height) except *Poncirus* which is deciduous in nature. The root system of the crop is single tap root with lateral roots growing horizontally, providing a surface mat of feeding root. Leaves are normally unifoliate but in *Poncirus* it is trifoliate in nature. Flower are solitary or in small clusters of cymes in leaf axil. Flowers are normally born on new/current season growth. Fruit are modified berry, commonly called as

hesperidium. Fruit have 3 layers- exo, meso and endocarp. Exocarp is the outer layer rich in chloroplast and oil glands, called as flavedo. Mesocarp is the middle layer (colourless spongy portion of fruit ring) rich in sugar, pectine, ascorbic acid and glucoside- called as albedo while endocarp is the segments with multicellular hairs which are filled with juice and surrounded with transparent membrane. Edible part of the fruit is juice vesicles. Seeds are polyembryonic in nature with one zygotic and several non-zygotic embryos (exception- pummelo, citron and Tahiti lime as they are monoembryonic in nature).

Flowering time: under subtropical climate it flowers in Spring (Feb- April). However, in south India it flowers twice in a year (Dec- April and again Sep- Dec) and in central and western India, trice in a year (February, June and October). Flowering in Lime & lemon occurs throughout the year. On the basis of flowering they are classified as *Ambe* bahar (flowering in February), *Mrig* bahar (flowering in June) and *Hasta* bahar (flowering in October).

Bahar treatment:

Objective: Treatment of the plant to get fruitful yield in any of the 3 flowering season. Mainly practiced in south and central India.

Methods

1.Root exposure and with holding of irrigation- expose the root to sun (1-2 months before flowering) by removing 7-10 cm soil around 40-60 cm radius of the trunk. This will results in the wilting of entire leaves . At this stage roots will again covered with mixture of soil and FYM and irrigate immediately. This will helps in the commencement of new vegetative growth instead of flowering which will flowers and fruits profusely in the subsequent season.

In light sandy and shallow soil- exposure of root- not practiced. Only withholding of irrigation for 2-3 weeks is practiced

Choice of bahar- depend of the grower to get max. profit. In central India, farmers mainly prefer mrig bahar, so that plants are forced to rest in April-May and no water is required at that time. For better quality fruit- hasta bahar

2.By chemical means- Application of NAA @ 250-600 ppm and 2,4-D @ 100-300 ppm at flowering of undesirable bahar- cause drop of entire flower, resulting heavy flowering and fruiting at desirable bahar.

Climate: Citrus fruits in India are cultivated under varied agro-ecological conditions right from arid and semiarid areas of southwest region to humid tropical climate of northeast India. Citrus trees are evergreen, grown in truly subtropical climates of the world although in tropical regions of the world they tend to produce cyclic growth flushes and hence regulating cropping in tropical areas for forcing them into concentrated bloom needs judicious management of water deficit stress according to soil type and growing season. Citrus fruits grow best between a temperature range of 13°C to 37°C. Temperatures below – 4°C are harmful for the young plants. Soil temperature around 25°C seems to be optimum for root growth. High humidity favours spread of many diseases. Frost is highly injurious. Hot wind during summer results in desiccation and drop of flowers and developing fruits. Barring these limitations citrus is grown in all subtropical and tropical areas of the world. The sub-tropical climate is best suited for citrus growth and development. Khasi and Darjeeling mandarins are grown in high altitudes upto 2000 m as it is adapted to a cooler climate.

Soil: Citrus plants are grown in a wide range of soils ranging from sandy loam or alluvial soils of north India to clay loam or deep clay loam or lateritic/acidic soils in the Deccan plateau and north-eastern hills. Citrus orchards flourish well in light soils with good drainage properties. Deep soils with pH range of 5.5 to 7.5 are considered ideal. However, they can also be grown in a pH range of 4.0 to 9.0. High calcium carbonate concentration in feeder root zone may adversely affect the growth.

Planting Material: Availability of quality planting material is of utmost importance in citrus cultivation. Citrus plants are very sensitive to various biotic and abiotic stresses. Therefore selection of an ideal rootstock is a continuing challenge for the citrus industry of India. Currently used rootstocks viz. rough lemon and Rangpur lime have gone through a lot of variation over the last five decades. Therefore ideal selections developed from the conventional rootstocks by National Research Centre for Citrus (NRCC), Nagpur and at other places under

State Agriculture Universities may be obtained for propagating quality planting material. For budwood selection, disease free mother plants developed from the elite progeny of known pedigree through shoot tip grafting method available at NRCC, Nagpur may only be used.

Primary nursery beds are prepared on light fertile soils or in the HDPE trays under shade net structures. Selection of nucellar seedlings is done by eliminating weak seedlings, off types and non uniform seedlings in 2-3 stages in the nursery beds. Secondary nursery seedlings may be raised in polythene bags also as they become ready for plantation in the main field after attaining the height of about 30-40 cm after one year.

Land preparation: Land needs to be thoroughly ploughed and levelled. In hilly areas, planting is done on terraces against the slopes and on such lands, high density planting is possible as more aerial space is available than in flat lands. Since citrus trees are highly sensitive to water logging and water stagnation during rainy season providing drainage channels of 3-4 feet depth along the slopes around the orchard is essential.

Plant density

Mandarin (*Citrus reticulata* Blanco) Normal spacing – 6 m x 6 m ; Plant population – 277/ ha
Sweet orange (*Citrus sinensis* Osbeck) Normal spacing - 5 m x 5 m, 5.5 x 5.5 m; Plant population – 400/330 per ha
Limes/lemons (*Citrus aurantifolia* Swingle &*Citrus limon*) Normal spacing – 6 x 6 m / 5 x 5 m, Plant population – 277/400 per ha
In light soils, spacing will be 4.5 x 4.5 m or 5 x 5 m

Planting

The best season of planting is June to August. Pits of the size of 1m x 1m x 1m may be dug for planting seedlings. 15-20 kg of FYM and 500 g of super phosphate is applied per pit while planting. With good irrigation system, planting can be done in other months also.

Irrigation

Citrus requires critical stage watering in the initial year. It further reduces fruit drop and increases the fruit size. Diseases like root rot and collar rot occur in flooded conditions. Light irrigation with high frequency is beneficial. Irrigation water containing more than 1000 ppm salts is injurious. Quantity of water and frequency of irrigation depends on the soil texture and growth stage. Micro-irrigation systems not only save water and nutrients but also ensure good retention of fruits during crucial stages of crop growth in March – April even in situations where water is not a limitation.

Manures & fertilizers

Manuring is done in three equal doses three times in a year in February, June and September. The recommended manurial and fertilizers doses are given below-

FYM	I Yr	II Yr	III Yr	IV Yr	V Yr	VI Yr	VII Yr onwards
Kg/plant	20	10	15	20	25	30	40

Nutrients	I Yr	II Yr	III Yr	IV Yr	V Yr	VI Yr onwards
Nitrogen	100	200	300	400	450	500
Phosphorus	50	100	150	200	200	250
Potash	25	50	75	200	200	250
$ZNSO_4$	25	25	50	50	100	150

$FeSO_4$	25	25	50	50	100	150
$MnSO_4$	25	25	50	50	100	150

Interculture

Ploughing, spading of basins, weed control, etc., are important inter-culture operations for soil aeration and health. Chemical control of weeds with pre-emergence weedicides like diuron (3 Kg/ha), simazine (4 Kg/ha), glyphosate 4 l/ha, paraquat (2 l/ha), etc. may also be adopted.

Intercrops

Leguminous crops like soybean, gram, groundnut, cow peas, french bean, peas etc., may be grown in citrus orchards. Intercropping is advisable during the initial three-four years after planting.

Training and Pruning

In order to allow the growth of a strong trunk, initially shoots upto 40-50 cm from the ground level should be removed. The centre of the plant should remain open. Branches should be well distributed to all sides. Cross twigs and water suckers are to be removed early. The bearing trees require little or no pruning. All diseased, injured and drooping branches and dead wood are to be removed periodically.

Harvesting

There are two main crops in mandarins and sweet oranges. One is called as *Ambiabahar* (mango flowering) the flowering of which occurs in the month of January (at the time of flowering of mango hence the name *Ambia*) the fruits of which are available in the months of October-December The other crop is *Mrigbahar*(Monsoon bloom) the flowering of which occurs in the month of June-July and the fruits are harvested during February-April. Mandarins and sweet oranges normally take 240-280 days to arrive at maturity. Mature fruits at colour break stage are picked up in 2 - 3 intervals of 10-15 days. Limes and lemons take 150-160 days for maturity. There may be 2 or 3 crops in a year in limes and lemons.

Yield

Mandarin: Commences from the 5th year with about 50 fruits per tree and stabilises in the 8th year. Average production is about 700-800 fruits per tree after stabilisation.

Sweet Orange: Commences from 5th year with 40-50 fruits per tree& stabilises around the 8th year. Average production is about 500-600 fruits per tree after stabilisation.

Lime/Lemon : Commences from the 3rd year with 50-60 fruits per tree & stabilises in the 8th year. Average production is about 1000-1500 fruits per tree after stabilisation.

Economic life of plantation: 15 to 25 years

Lecture 6: Grape

Botanical Name:	*Vitis vinifera*.
Family:	Vitaceae
Origin:	Black sea- Caspian sea
Type of fruit	Berry
Edible part:	Mesocarp and placenta
Inflorescence:	Panicle
Chromosome no.:	*vinifera*=38 and *rotundifolia* = 40

Grape is one of the oldest fruits being grown by man. However, it was introduced into north India from Iran and Afghanistan in 1300 AD by the Muslim invaders; and into south India in 1832 by the Christian missionaries from France. Grape was well known to people even in ancient India but it was not commercially cultivated until the 14th century.

Presently grape cultivation is concentrated in the peninsular India, accounting for 90% of the total area. Major grape-growing states are Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and the north-western region covering Punjab, Haryana, Delhi, western Uttar Pradesh, Rajasthan and Madhya Pradesh.

Climate: Temperature, humidity and light are important for grapes. Hot and dry climate is ideal. Areas with high rainfall are not suitable. Mild temperature, not exceeding 35 C in summers, impairs the fruiting of vinifera grapes, particularly, in Thompson Seedless. Higher night temperatures (above 25 C) during ripening hamper the colour development in coloured grapes. Under high humid conditions, the vines put forth excessive vegetative growth at the expense of fruiting. Berries do not ripen properly. Disease incidence is high. The total amount of rainfall is not the criterion, but the timing frequency and duration of rainfall are important considerations for grape cultivation. Rains associated with cloudy weather and poor sunlight during 45-60 days after back pruning in the tropical India reduce the fruitful buds in a vine. Rainfall during flowering and berry ripening cause enormous damage to gapes. If rains coincide with flowering, the panicles are destroyed by downy mildew. Rains during ripening cause berry cracking and rotting.

Soil: Grapes are grown on a variety of soils in India, alluvial in north, heavy black clay in Maharashtra and north Karnataka, red loam in southern Karnataka and Tamil Nadu and very light sandy locally called ‘Chalka’ soils in Andhra Pradesh. Soil with good drainage and water-holding capacity in a pH range of 6.5-7.5 is ideally-suited for grapes. Presence of excess salts, particularly sodium and free calcium is detrimental for grapes. Vines become weak and their productive life span is reduced.

Varieties: More than 20 varieties are under cultivation. However, only a dozen are commercially grown. They can be grouped under 4 categories based on colour and seeds.

They are:

Coloured seeded	Bangalore Blue (Muscat), Gulabi
Coloured seedless	Beauty Seedless and Sharad Seedless
White - seeded	Anab-e Shahi, Dilkhush (clone of Anab-e Shahi)
White - seedless	Perlette, Pusa Seedless, Thompson Seedless, and Its clones Tas-A-Ganesh, Sonaka andManik Chaman

Other popular varieties are	Arka Hans- known for making white wine, Kishmish Beli- famous for making raisin
Hybrids	Pusa Navrang (Angenine x Rubi Red), Pusa Urvashi (Hur x Beauty Seedless, Arkavati (Black Champa x Thompson Seedless, Arka Hans (Anab-e Shahi x Thompson Seedless)

Currently, Thompson Seedless is the ruling grape, occupying 55% of the area with its clones. Bangalore Blue occupies approximately 15% of the total area while Anab-e-Shahi and Dilkhush (15%), Sharad Seedless (5%), Perlette (5%) and Gulabi and Bhokri together (5%).

Propagation

Grape is commercially propagated by hardwood stem cuttings. Four - noded cuttings from well mature canes on proven vines are made. The diameter of cuttings should be 8-10mm. Cutting are mostly obtained from October pruning in the peninsula. Rooting of cuttings is not a problem. However, Thompson Seedless roots are poorer than Anab-e-Shahi or Bangalore Blue but to increase the rooting of stem cuttings, they should either be soaked or dipped to cover the basal buds in IBA solution. For overnight soaking, 500 ppm IBA solution is used, while 2000 ppm solution is used for quick dipping for 10sec. before planting the cuttings. Quick dip method is preferred. Cutting after treating with IBA should be planted in the nursery or directly in the field.

Rootstock: Rootstocks are employed for grapes to overcome salinity, nematode damage and to impart vigour to vines. In normal soils with good and adequate water for irrigation, rootstock is not necessary. In nematode-prone soils, the rootstock **1613** can be used for Anab-e-Shahi or Thompson Seedless. In saline soils, **Dog ridge** is better. Use of Dog ridge in non-saline, nematode-free soils, particularly under mild climatic conditions makes the vines barren by imparting excess vigour. **Temple** rootstock is used for resistance against Pierce's disease.

Planting: Before plating the rooted/UN rooted cuttings in the main field, the land is cleared of all bushes and levelled. Trenches or pit 1m wide and 75 cm deep are opened. When plant spacing within a row is less than 2m, continuous trenches are made. The pits/trenches are filled with farmyard manure, green manure/leaf-mould, bone-meal (1kg), super phosphate (1kg) and allowed to settle by watering. Cuttings are planted in their position by opening a small pit. A mixture of sand, well-rotten manure and super phosphate (0.5kg) is packed around the cutting in the pit. The soil around the planted cuttings is drenched with a solution of Chlorpyriphos.

October is ideal time for planting the unrooted cuttings directly in the field. Rooted cuttings are planted in January-February. Spacing of vines depends on the variety, vigour of vines and system of training Generally Anab-e-Shahi and Dilkhush vines are spaced at 3.3 x 6.6m or 5.0m x 5.0m. The spacing of vines of seedlings varieties varies from 1.2m to 2.0m within a row and 2.7 to 3.6m between rows when trained to 'T' or 'Y' trellis. For Thompson Seedless, the spacing of 1.8m x 3.0m is ideal for bower and 'Y' trellies trained vines respectively.

Flowering: The flowers in grapes are borne in clusters. They are perfect, pistillate or staminate. Berry set from pollination, fertilization and seed development. In seedless varieties berry develop by parthenocarpy. The type of parthenocarpy in grape is vegetative (Black Corinth) and stenospermocarpy (Perlette, Beauty Seedless, Pusa Seedless, Delight, Thompson seedless). Most of the grape varieties are self pollinated but varieties like Banqui, Abyad and Hur having pistillate flowers require cross pollination.

Training: Different systems of training-head, kniffin, telephone, V, expanded Y and gable-are in vogue in India. Productive potential of vines is better exploited on bower than on any other system of training. But this system is expensive, encourages diseases, and is not suitable for mechanization of cultural operations. On head, Kniffin and telephone systems of training not

only the yields are low but the fruits are exposed to sun resulting in sun-burn, but the yield is the same. The expanded Y with long arms and gable system connecting the side arms of adjacent rows are best-suited for training seedless grapes, since these systems posses the advantages of bower and at the same time do not have disadvantages associated with it.

Pruning: In north India, vines are pruned in winter (December-January). Half of the canes are pruned to renew spurs and the rest for fruiting canes. One or two buds from the cordon (arm) are retained in renewed at spurs and 12 buds are retained on fruiting canes. The numbers of buds left on fruiting canes depend on variety and thickness of cane. Thick canes are pruned longer and the thin shorter. The fruited canes are pruned to renewal spurs and the canes developed from renewal spurs are pruned to fruiting canes in the next winter.

In Maharashtra, Andhra Pradesh and north Karnataka, vines are pruned twice (April and October). The April pruning is generally termed as back pruning or foundation pruning. While October pruning is called fruit pruning or forward pruning. All the canes are pruned to spurs at back pruning, irrespective of the variety or cane thickness. The number of buds retained on a cane at forward pruning depends on variety and cane thickness.

Manuring and fertilization: The nutrient status of vines is far in excess than required leading to certain nutrient imbalances; particularly Mg deficiency as a result of heavy doses of K. Grape requires more K than N which in turn is required more than P. However, P is required at the time of fruit-bud formation when N requirements are less. The N is required more for shoot growth during the fruiting season. Whereas K is required after bud differentiation for shoot maturity and increasing the size of fruit-bud. It is also required after berry set until ripening. Heavy dose of cattle manure is applied to improve soil structure and to increase its moisture-holding capacity. About 25-50 tonnes of well-decomposed cattle manure, 5 tonnes of oil cake (deoiled) and 1,200 kg of organic mixture should be applied every in a hectare crop. When such organic nutrients are applied, the inorganic doses are proportionately reduced.

Among the nutrient deficiencies, Mg deficiency is universal. About 100-200 kg of magnesium sulphate/ha/year should be applied depending upon the severity of its deficiency. While 50 kg is applied after 30 days of April pruning, the rest is applied in 2 splits during the fruiting season once at berry set and again after a month.

Irrigation: Grape is a shallow feeder. Light and frequent watering is better for grapes. Water requirement of grape are very high during berry growth. This period coinciding with hot and dry weather, more water is required at this stage. Least water is required during fruit-bud formation. This period if coincides with cloudy weather and rains, watering are totally to be stopped. Reduced irrigation during ripening, i.e. (one month prior to harvesting) improve the quality of grapes and hastens ripening. Too much stress during ripening can also increase the berry drop at and after harvesting.

Weed control: Farmyard manure and compost are the major sources of weed seeds from outside. The problematic weeds in vineyards are Bermuda grass (*Cynodon dactylon*) and nut grass (*Cyperus rotundus*). The weed intensity is less in bower trained vineyards. Mechanical control is most common means of weed control in India. Dhaincha and sun hemp are grown as intercrops to check the weeds in vineyards trained to T, V or Y trellises. Post-emergent weedicides-Paraquat (7.5 kg/ha) or Glyphosate (2.0 kg/ha), is also recommended. Glyphosate offers a long time control of weeds as compared to Paraquat.

Use of growth regulations: Growth regulators CCC, GA and hydrogen cyanamide are being used commercially in grapes. The CCC is used to suppress the vigour of vines and increase the fruitfulness of buds. It is sprayed at 500 ppm concentration at 5-leaf stage after back pruning. If weather is cloudy, cool and rainy, it is sprayed on the foliage once again at 10-leaf stage. Gibberallic acid (GA) is used invariably in all seedless varieties. It is sprayed at 10 ppm to elongate the clusters, 22-25 days after forward pruning (4-5_leaf stage). It is also sprayed on clusters @ 40 ppm at 50% bloom stage for thinning the berries and improving yield and fruit quality. Hydrogen cyanamide is used to hasten and increase the bud-break at winter pruning

Harvesting and Yield: Grape is a non climacteric fruit and are harvested when fully ripe, since they do not ripen after harvesting. In seeded grapes, the seeds become dark brown when they are fully ripe, while in seedless varieties, their characteristic berry colour develops fully.

The productivity of grape 21.1 tonnes/ha of India is highest in the world. Grape variety Anab-e-Shahi has recorded yield as high as 92 tonnes/ha, whereas Thompson Seedless has 48 tonnes/ha. The average yield of Anab-e-Shahi and Bangalore Blue is 40-50 tonnes/ha, while that of seedless varieties is 20 tonnes/ha.

Products: About 80% of the grapes produced in the world are used for wine making. But in India, most of the grapes produced irrespective by variety, are consumed fresh. Negligible quantities of Bangalore Blue are crushed to make juice and wine for household consumption. Wine is also produced in India with French collaboration by some private industries growing certain French varieties.

Raisins are the only processed products in India. However the quality of the grapes grown in India is not good enough for making of raisins, which require 24 to 28 percent sugars, which includes no sucrose. The sugar content of grape grown in India varies from 13-22 percent. Approximately 30% of seedless grapes are dried to produce 15,000 tonnes of raisin. Golden bleached raisins are produced by shade drying the clusters after dipping in either boiling solution of sodium hydroxide (0.2-0.3%) and exposing to sulphur fumes. Dipping in soda oil (dipping oil) containing ethyl oleate and potassium carbonate and shade drying is the most common method of preparing raisins in India. Seeded grapes of Anab-e-Shahi are also dried in very small quantities to make raisins.

Physiological disorders

Of physiological disorders, uneven ripening, post-harvest berry drop, flower-bud and flower drop and pink berry formation are major ones.

Uneven ripening: Presence of green berries in a ripe bunch of coloured grapes is called uneven ripening. It is varietal character and a problem in Bangalore Blue, Bangalore Purple, Beauty Seedless and Gulabi grapes. Within a variety this problem varies from bunch-to-bunch. Generally inadequate leaf area and non-availability of reserves to a developing bunch is the reason. Cultural practices like cluster thinning, girdling and use of growth regulators can reduce uneven ripening. Application of Ethephon (250 ppm) at colour break stage is recommended to reduce the problem.

Postharvest berry drop: This is due to weak pedicel attachment to the berries. This is common in Anab-e-Shahi, Cheema Sahebi and Beauty Seedless. Spraying of NAA (50 ppm), a week prior to harvesting can minimize the post-harvest berry drop.

Flower-bud and flower drop: When panicles are fully expanded, the flower buds drop before the fruit set. This is common in north India but not in the south. The reasons for this disorder are not known. Stem girdling about 10 days prior to full bloom can reduce and problem.

Pink berry formation: It is a common disorder in Thompson Seedless and its clone Tas-A-Ganesh in Maharashtra. Pink blush develops on a few ripe berries close to harvesting. The pink colour turns to dull red colour and the berries become soft and watery. They do not stand for long after harvesting. Although the definite cause of the disorder is not known, it is recommended to spray a mixture of 0.2% ascorbic acid and 0.25% sodium diethyl dithiocarbamate at fortnightly intervals commencing berry softening.

Some important points you need to know about grapes

- Deciduous in North India while as evergreen in South India .
- The cane cut back to one or two buds to produce fruiting wood for the next year is called **Renewal Spur**
- *Vitis vinifera* is self pollinated *Vitis rotundifolia* is cross pollinated

Lecture 7: GUAVA

INTRODUCTION

Guava (*Psidium guajava*) is one of the important commercial fruits in India. It is the fourth most important fruit after mango, banana and citrus

Family: Myrtaceae

Chromosome no. X=11, 2n=22, 33

Inflorescence: Solitary

Type of fruit: Berry

Origin

Guava is native to **tropical America** where it occurs wild. It was introduced in India in the seventeen century.

Economic Importance

The fruit is a good source of vitamin C, pectin, calcium and phosphorus. Vitamin C content is the highest in fruit peel at mature stage. The fruit is used for the preparation of processed products like jams, jellies and nectar. Guava jelly puree is very popular for its attractive purplish-red colour, pleasant taste and aroma. The puree can be used in juice, cakes, puddings, sauces, ice-cream, jam and jelly. Fruits can be preserved by canning as halves or quarters, with or without seed core (shells). Good quality salad can be prepared from the shell of ripe fruits.

Agro-Climatic Requirements

Guava is grown in both tropical and sub-tropical regions upto 1,500 m. above m.s.l. It tolerates high temperatures and drought conditions prevalent in north India in summers. However, it is susceptible to severe frost as it can kill the young plants. An annual rainfall of about 100 cm. is sufficient during the rainy season (July-September). Rainfall during the harvesting period deteriorates the quality of fruits.

Soil

Guava adapts well to a wide range of soils. Well-drained, light sandy loam to clay soils is good. Since it is a hardy fruit crop, it can be grown on alkaline soils wastelands etc. It is sensitive to waterlogged conditions. It tolerates a wide range of pH from 4.5 to 8.5.If the soils are having a pH of 7.5 and above there are more chances of getting guava wilt. Some varieties like Lucknow-49 can be grown in saline soils also.

Varieties Cultivated

Important guava varieties cultivated in different states of India are given below :

State		**Varieties grown**
Andhra Pradesh	-	Allahabad safeda, Lucknow 49, Anakapalli, Banarasi, Chittidar, Hafshi, Sardar, Smooth Green, Safed Jam, Arka Mridula
Madhya Pradesh	-	L-49, Allahabad safeda, Gwalior-27, Hafshi, Seedless Chittidar
Jharkhad	-	L-49, Allahabad safeda
Karnataka	-	Allahabad Safeda, L-49, Araka Mridula, Araka Amulya, Bangalore, Dharwar

Assam	-	Am Sophri, Madhuri Am, Safrior Payere
Bihar & Jharkhand	-	Allahabad Safeda, Apple Colour, Chittidar, Hafshi, Harijha, Sardar, Selection-8, Pant Prabhat
Maharashtra & Gujarat	-	Nagpur seedless, Dharwar, Dholka, Kothrud, L-24, L-49, Nasik, Sindh
North-eastern States	-	Allahabad Safeda, Sardar, Red Fleshed.
Tamil Nadu	-	Anakapalli, Banarasi, Bangalore, Chittidar, Hafshi, Nagpur Seedless, Smooth Green
Uttar Pradesh	-	L-49, Allahabad Safeda, Lucknow Safeda, Apple Colour, Chittidar, Red Fleshed, Allahabad Surkha, Sardar, Mirzapuri Seedless, CISH-G-1, CISH-G-2, CISH-G-3
West Bengal	-	L-49, Allahabad Safeda, Dudhe Khaja, Gole Khaja, Kabli, Baruipur, Chittidar,

- Lalit and Hafshi are red fleshed cultivar in guava
- Chittidar is red dotted skin cultivar in guava
- L-49 (Sardar Guava) is a chance seedling selection from Allahabad safeda in 1927 made at Ganesh Khind Fruit Research Station Pune by G.S.Cheema and Deshmukh.
- L-49 is tolerant to guava wilt.
- Kohir safed (Kohir × Allahabad safeda) and Safed Jam (Allahabad safeda ×Kohir) are improved cultivars of guava developed in sangareddy, A.P.

Rootstocks

1. Psidium friedrichsthalianum (Chinese guava) Dwarfing and wilt resistant
2. Psidium Pumilim Most dwarfing
3. Strawberry guava/cattleya guava (P. cattleianum is considered as an important species for use as a root stock
4. Aneuploid 82- Pusa Srijan (Semi dwarfing rootstock)

Flowering and fruiting

The guava bears flowers solitary or in cymes of two or three flowers, on the current seasons growth in the axils of leaves. The bearing twigs grow a few centimeters long, putting forth 4-5 pairs of leaves. The blooming period varies from 25-45 days depending on the cultivar, season and region. The initial fruit set is quite high and approximately 80% of flowers set fruits. Afterwards due to severe fruit drop only 34 - 56 per cent of fruits reach maturity. In cultivars like seedless, the final retention is as low as 6 percent.

Propagation

Plants are vegetatively propagated by Stooling, inarching or air layering. Now wedge grafting is also reported successful in guava.

Planting Season

Planting is done during the rainy season. June-July is the ideal time for planting the layers and seedling.

Spacing

The plants are usually planted at a distance of 5-8 m. The exact planting distance is decided according to variety, soil fertility and availability of irrigation facilities.

Standard spacing is 6 m. x 6 m. accommodating 112 plants/acre. By increasing the plant density, productivity can be increased. In the model scheme, a spacing of 6 m. x 6 m. with a population of 110 plants per acre has been considered which was commonly observed in areas covered during a field study.

High density planting causes erect growth of branches making the plant tall, compact and also give higher yield/unit area in early years of fruiting. Plants are planted at a distance of 2.5 m in HDP.

Planting Method

Square system of planting is generally adopted. Pits of 1x1x1m. size are dug before the monsoon and filled with a mixture of farmyard manure and soil.

Nutrition

Time of fertilizer application depends on the region and crop variety. In north India, fertilizer is applied in the first week of May for rainy season crop and in first week of July for winter season crop. The plants are manured twice a year, first during June-July and second by during October.

A fertilizer dose of 600 g. N, 400 g. K in Northern Region, 260 g. N, 320 g. P and 260 g. K in Eastern Region, 900 g. N, 600 g. P and 600 g. K in Southern Region and 600 g. N, 300 g. P and 300g. K/plant /year in Western Region is recommended.

Irrigation

Guava is mostly grown under rainfed condition. During winter season, irrigation is provided at an interval of 20-25 days and in the summer months it is provided at an interval of 10-15 days by the ring method.

Drip Irrigation

Drip irrigation has proved to be very beneficial for guava. About 60% of the water used for irrigation is saved. Besides substantial increase in size and number of fruits is observed.

Training & Pruning

Training of plants in young stage is essential in order to build a strong framework and to avoid weak crotches. Fruiting trees are pruned to check overcrowding in the orchard. The plants are trained as low headed trees to facilitate multiple hand pickings. Guava is generally trained to **modified leader system.** Pruning is usually recommended after harvesting or in spring. Summer pruning is generally avoided as the plants get damaged due to sun burn.

Bending

It is a common feature that in the guava trees branches growing upright and tall don‘t bear at all. In such cases, straight-growing branches may be bent and tied on the pegs driven on the ground. In bent branches dormant buds are activated and induced to bear flowers and fruits heavily. This method is successful especially in varieties, which grow erect and bear little fruits.

Intercultural Operations

Weeds are usually removed by shallow cultivation. Green manuring is usually done during rainy season. Pre-emergence use of diuron (1.6 kg./ha.), oryzalin (1.67 litres/ha.), simazine (1.6 kg./ha.) or atrazine (1.6 kg./ha.) has been found to be effective in control of weeds in guava orchards.

Mulching

Dry leaves or straw are used as mulching material. Mulching can also be done either with black polycthylene sheet or with organic materials. Mulching the soil at least twice a year helps in conserving moisture and improving the fruit quality.

Inter-cropping

Leguminous crops or vegetable can be grown as intercrops during the first three years of planting provided irrigation facility is available.

Growth Regulators

The winter crop is much superior in quality compared to the monsoon crop. Farmers often reduce monsoon crop by deblossoming to get a higher price. This is done by growth regulators like maleic hydrazide on spring flush of flowers. Growth regulators like NAA, NAD and 2, 4D have been found to be effective in thinning of flowers and also manipulating the cropping season.

Plant Protection Measures

Insect Pests

The insect pests mostly observed are fruit fly, stem borer, bark eating caterpillar, thrips, nematodes, mealy bug and scale insect. Spraying with malathion (2ml.), phosphamidon (0.5ml. per ltr. of water), monocrotophos, dimethoate etc. has been found to be effective in most cases. Apart from that adoption of suitable cultural practices and destruction of infected plants needs to be done.

Diseases

The main diseases reported are wilt, fruit canker,fruit rot, anthrachose and grey leaf spot. Application of Carbendazim / Thiophanate methyl (1g./l) or Kavach / Mancozeb (2 g/l) depending upon the type of infection has been found to be effective in controlling the diseases.

Disorders

Fruit drop is a serious disorder in guava resulting in about 45-65% loss due to different physiological and environmental factors. Spraying of GA has been found to be effective in reducing the fruit drop in guava.

Bronzing of guava has been observed in places having low soil fertility and low pH. Affected plants show purple to red specks scattered all over the leaves. Under aggravated condition, total defoliation and fruits characterized with brown coloured patterns on the skin, with reduced yield are noticed.

Foliar application of 0.5% diammonium phosphate and zinc sulphate in combination at weekly intervals for two months reduces the bronzing in guava. Pre-flowering sprays with 0.4% boric acid and 0.3% zinc sulphate increase the yield and fruit size. Spraying of copper sulphate at 0.2 to 0.4% also increases the growth and yield of guava.

Harvesting and Yield

The plants start bearing at an early age of 2-3 years but they attain full bearing capacity at the age of 8-10 years. The yield of a plant depends on its age, cropping pattern and the cultural practices. A 10 year old plant yields about 100 to 150 kg. of fruits every year. If both rainy and

winter season crops are taken, more yields may be obtained in the rainy season. 12-15 t/ha in conventional where as 25-30 t/ha yield are reported.

Guavas are harvested throughout the year (except during May and June) in one or the other region of the country. However, peak harvesting periods in north India are August for rainy season crop, November- December for winter season crop and March-April for spring season crop. In the mild climatic conditions of the other parts of the country, the peak harvesting periods are not so distinct.

Guava fruits develop best flavour and aroma only when they ripen on tree. In most of the commercial varieties, the stage of fruit ripeness is indicated by the colour development which is usually yellow. For local markets, fully yellow but firm fruits are harvested, whereas half yellow fruits are picked for distant markets. Fruits are harvested selectively by hand along with the stalk and leaves.

Guava fruits can be stored for 4 weeks at 8-10 degree Celsius and 80-90% humidity.

LECTURE 8: CROP REGULATION IN GUAVA

Undernaturalconditions,guavatreeproducesflowersandafruittwiceinayearin NorthIndia,butinSouthandWesternIndiaitisthricei.e.almostthroughouttheyear, whichresultsinnorest period and ultimately guavatree, bearssmallcropsat different timesoftheyear.Under north India, two distinct seasons of flowering spring summer (April-May) and in monsoon (July-August) occur from which fruits ripen during rainy and winter season, respectively. The winter season crop is considered superior in quality than rainy season crop. A good harvest is possible only if crop is regulated to single season (bahar).

The pattern offloweringandfruitingperiods inguava are:

Ambe-bahar: WhenguavatreeflowersduringMarch-Aprilorspringseason,this floweringperiodisknownasAmbe-bahar.ThefruitsripefromJuly-Septemberinrainy season.Thefruitsobtainedduring thisseasonareinsipid,wateryandpoorinquality i.e.taste andkeeping quality.

Mrig-bahar:WhenguavaproducesflowersinJuly-Augustormonsoon,this-flowering periodisknownas*Mrig-bahar*.ThefruitsripefromNovember-Januaryin the winter. Thefruits obtainedduringwinter are excellentinqualityand therefore,theguava trees are madetoproducethe*Mrig-bahar*flowering only.

Hasth-bahar:Sometimes,guava treeproducesflowersinOctoberareknownas *Hasth-bahar*.ThefruitsripefromFebruary-April.The equalityisgood,butyieldisvery low.However,itfetchesgoodprice. Thisbaharinguavaisnotverycommon. Itis mostlyachancecrop.Hast-bahar is observedinwestern andsouthern India.

Cropregulation(BaharTreatment): ThroughoutIndia,*Mrig-bahar*ispreferredover ambeandHast-bahars.Therefore,itbecomenecessarytoregulateflowering,sothat *Mrig-bahar* can produce heavy flowering and fruits areavailable in winter.The practicesfollowedfor taking*Mrig-bahar*are:

Restrictingirrigationwater: ThetreesshouldnotbegivenirrigationfromFebruaryto middleofMay. Doingso,thetreeshedsitsleavesduringhotseason(April-May)and goestorest. Duringthisrestperiod, treecanconservefoodmaterialinitsbranches. InthemonthofJunetreeiswellcultivatedandmanuredfollowedbyirrigation. After about20-25daysthetreeblazeintoprofuse blossoms. Thefruitsmatureduring winter.

Exposing roots: Carefullyuppersoilaroundthetrunkabout45-60cmradiusis removed,sothattherootsareexposedtothesunwhichresultsinreductioninsupply ofsoil moisturefromthesoilto the top and therefore,theleaves begintoshed and the treegoestorest. Afterabout3-4weekstheexposedroots areagaincoveredwiththe soil. Manuring andwateringmaybefollowed.

De-blossoming: Itcanbedonewiththeuseofgrowthregulators. Spray urea 10 percent or napthale acetic acid (NAA)@ 600 ppm during May when maximum flowers have opened. Each tree needs about 10-12 liters of solution. Deblossmingcan alsobedonemanuallyonsmallscale. Whenflowersof*Ambe-bahar*arede-blossomedorthinned,thetreebecomemore potentialto producemoreflowers andfruits in*Mrig-bahar*.

Pruning: Pruning of terminal portions of the shoots up to 20 or 30 cm between 20 to 30 April avoids completely the rainy season crop**.**

Inorganic fertilizers: Apply inorganic fertilizers during the month of June to encourage growth in July-August for getting maximum flowering during August-September for winter season crop**.**

Lecture 9: SAPOTA

- Botanical name — *Achraszapota*
- Family: — Sapotaceae
- Origin: — Mexico(Tropical America)
- Inflorescence: — Solitary
- Type of fruit: — Drupe
- Chromosome no: — X=13, 2n=26
- Edible portion — Mesocarp

INTRODUCTION

Sapota (*Achraszapota*) commonly known as chiku is mainly cultivated in India for its fruit value, while in South-East Mexico, Guatemala and other countries it is commercially grown for the production of chickle which is a gum like substance obtained from latex and is mainly used for preparation of chewing gum. Sapota, when fully ripe, is delicious and is eaten as dessert fruit. The pulp is sweet and melting.

Origin

Sapota is originated in tropical America, introduced in 1898 in the state of Maharashtra now leading state in its production and productivity.

Economic Importance

The fruit is a good source of digestible sugar (15-20%) and an appreciable source of protein, fat, fibre and minerals (Ca, P and Fe.) Sapota pulp is used for making sweets and halwas. It is also an ingredient of fruit salads and milk shakes. The milky latex secreted by unripe sapotafruits , known as chuckle forms the base for making chicklet and chewing gum.

Climate and soil

Sapota, a crop of tropical region, needs warm (10-38 C) and humid (70 % relative humidity) climate where it flowers and fruits throughout the year. However, if taken to subtropics or to places of higher elevation like in Punjab and Haryana, it gives only one crop from summer flowering in April and May. Under moisture stress also, it produces one crop only.

Soil

Alluvial, sandy loam, red laterite and medium black soils with good drainage are ideal for cultivation of sapota.

Flowering

Sapotastartsbearingsmallcropsfromsecondorthirdyear of planting but economical yields can be obtained from seventh year onward.Undertropicalconditions,flowersare seenalmostthroughouttheyear.However,therearetwomainseasonsofflowering i.e.March-April andSeptember-Octoberandhence,two harvestingseasons.

The flowers are protogynous in nature. Therefore planting of single sapota tree in home garden is not recommended. Sapota is a cross pollinated crop.

Varieties

There are about 41 varieties spread all over the country. However, commercially sapota industry is based on a few varieties and in some areas it is only monoculture like Kalipatte in Gujarat and Maharashtra. Distribution of cultivars in India according to region is given in table

Distribution of sapota cultivars in India

State	Cultivars
Andhra Pradesh	Pala, Kirtibarthi, Cricket Ball, Dwarapudi and Guthi
Gujarat	Jonavalasa
Maharashtra	Kalipatti, Bhuripatti, Pilipatti, DholaDiwani, Jhaumakhia and Cricket Ball
Karnataka	Kalipatti, Cricket Ball and Murraba
Tamil Nadu	Kalipatti, Cricket Ball, Kirtibarthi, DHS1and DHS2
Others	Guthi, Kirtibarthi, Pala, Co1, Co2 and PKM1
	Cricket Ball, Calcutta Special, Round, Oval and Baramasi

- **CO1** is a hybrid between **Cricket Ball** and **Oval**.
- CO2 is a clonal selection from Baramasi.
- PKM-1 is a clonal selection from Guthi. It is dwarf.
- CO1, CO2, Cricket Ball, Kallipati are resistant to leaf spot of sapota. While calcuttia Round is most susceptible.
- DHS1, DHS2, PKM2, PKM3 are hybrids of sapota.

Rootstocks

- Khirni (*Manilkarahexandra*)
- Adam's apple (*M. kauki*)
- Mahua (Madhucalatifolia)

Land Preparation

The land is ploughed two to three times and then leveled. Undulating land is divided into terraces and leveling is done. Tall and thick growing trees viz. mango, jamun, tamarind, silver oak and casuarinas are established on the wind-ward side or on all sides of the orchard. The plants for windbreak may be planted at a distance of 1.5 to 1.8 m. in the row.

Propagation and rootstocks

Sapota is propagated through seed, which has been the basis of its variability in India. But **inarching**, using Manilkarahexandra (called *khirni* or *rayan* in India) as a rootstock, is used in India. Air layering and softwood cuttings, using IBA (2,000ppm) treatment are also successful methods for sapota propagation. But plants which are raised through air layering or cuttings establish poorly and are vulnerable to wind damage.

Planting season

Planting can be done in any season provided irrigation facilities are available. Grafts are usually planted in the beginning of the rainy season. In areas which experience heavy rainfall the crop can be planted as late as September.

Spacing

On an average, 130 plants are planted at a spacing of 8.5m. High density planting with a spacing of 5x5 m. upto the age of 13 years has been adopted successfully.

In light soils, pits of 60x60x60 cm. size, whereas in heavy and gravely soils pits of 1x1x1 m. size are made in April-May and exposed to sun for a period of fifteen days. The pits are later on filled with well-rotten compost or farmyard manure, 3 kg. superphosphate and 1.5 kg. muriate of potash. The pits are then left to monsoon rains for settling and planting is done at appropriate tme.

Grafts, budded plants or layers are planted one in each pit and care is taken so that the bud joint or graft is at least 15 cm. above the ground level. After planting, stakes are provided to avoid

wind damage. Young plants are protected from the sun by making dry grass thatch on top and three sides excepting the south-east for sunlight.

Planting Method

Square system of planting is recommended. Contour planting is recommended in case of sloping land.

Training and pruning

A seedlings tree grows excellently giving a shape of an umbrella. However, plants raised through inarching require training for appropriate shape and frame work development. No definite system of training has been developed for sapota. Most trees are trained in **central leader system.**

Sapota being an evergreen tree requires no regular pruning but regulation of vegetative growth to improve productivity and quality of fruits is necessary. At times thinning of branches is affected in old plantation. Pruning in sapota is confined to open the tree to light, and removal of dead and diseased branches.

Nutrition

About 50 kg. of farmyard manure , 1 kg. N (1.5 kg. in case of rainfed varieties), 0.5 kg. P_2O_5 and 0.5 kg. K_2O /tree/year are applied and the dose is regulated on the basis of age of the tree and status of nutrients in soil especially of P and K. Under rainfed conditions, fertilizers are applied before the onset of monsoon. Under irrigated conditions, it should be applied in two splits, one half at the beginning of monsoon and the remaining half in the post-monsoon period (September-October).

Micronutrients

In case of Zn and Fe deficiency, organic manures, $ZnSO_4$ and $FeSO_4$ (0.5%) are applied.

Irrigation

Irrigation is provided at an interval of 30 days in winter and 15 days in summer.

Drip Irrigation

This system has been found to be beneficial in saving 40% water with 70-75 % higher income. This system is laid out with 2 drippers spaced 50 cm. from tree at an initial stage during the first two years and then 4 drippers about 1 m. away from the tree till it attains five years of age.

Intercultural Operations

The problem of weeds is common in young orchards. Application of 2 kg. bromacil and 2 kg. diuron/ha. as pre-emergence spray is effective in controlling weeds for a period of 10-12 months.

Inter-cropping

Inter-cropping with banana, papaya, pineapple and cocoa; french bean, peas, tomato, brinjal, cabbage, cauliflower, cucurbits is recommended depending upon the climate and irrigation facilities available.

Growth regulators

Fruit drop is a very serious problem in sapota. Spraying with GA_3 @ 50-100 ppm. at the time of flowering is quite effective for getting better fruit set and also preventing fruit drop.

Harvesting and Yield

Sapota takes about 7-10 1/2 months from anthesis to maturity of fruits depending on variety and climate. Fruits follow double sigmoid pattern of growth. Properly developed fruits have high TSS and sugar, and reduced acidity, astringency, latex and vitamin C. Maturity is decided on the

basis of ease with which brown scruff gets off the fruit surface and development of yellowish tinge intermixed wit corky brown color on the surface of the fruit. At this stage, practically no green tissue and milky latex are seen on fruits when scratched with nails. The fruits are hand picked or harvested with special harvester which has a round ring with a net bag fixed onto a long bamboo. Depending on management level, 15-20 tons fruits are harvested from a hectare.

Post-harvest management

Since sapota is a climacteric fruit, it has to be ripening artificially. Fruits are highly perishable and they undergo rapid ripening changes within 5-7days during which the fruits become soft, sweet and develop excellent aroma with decline in tannins, latex sapotin, aldehydes and acidity. These changes are associated with increase in production of ethylene, rate of respiration, catalase, peroxidase and PME activities. These changes can be regulated through chemicals, temperature and storage gas composition.

Harvested fruits should be cleaned of latex and scurf by washing in clean water to make them look attractive. Such fruits should be graded into big, medium and small sizes. Fruits should be tightly packed in cardboard boxes of 10 kg capacity with rice straw as padding material and with ethylene absorbents and transported quickly to wholesale markets. For extending shelf life and to avoid storage rots, fruits can be dipped in GA300 ppm + bavistin 1,000ppm solution at pre-packing stage. For uniform and rapid ripening ethephon (1,000ppm) can be utilized at 20`-25`C. Modified storage with 5-10 % (c/c) CO2 can be employed for long storage (21-25days). Refrigerated vans (12-23`C) should be utilized for long distance and export markets.

Physiological disorders

Wilt or die back is common where sapota cultivation is being extended to traditionally rice growing regions. Due to anaerobic conditions in monsoon and post monsoon season in such areas wilt is of common appearance aggravated by Fusarium spp. This can be controlled by effective drainage facility before planting.

The shape of fruit is related with number if seeds init which depend on conditions for pollination at anthesis. High temperature and rainfall during flowering cause oblongation of fruits. Therefore, cultivation of sapota in areas with extreme summer temperature should be avoided.

Sometimes fruits do not develop into their normal shape but develop a depression or furrow towards the calyx end. This symptom usually appears immediately after heavy rainfall and is aggravated by high intensity of irrigation. Therefore over irrigation should be avoided.

The fruits exposed to intense sunlight do not ripen uniformly, developing corkiness during winter. This is probably due to killing of hydrolyzing enzymes by alternation moisture accumulation and heating of fruit surface in winter. Thus its trees need to grow vigorously.

Plant Protection Measures

Insect Pests

Leaf webber, hairy caterpillars and bud worm are the common pests. Spraying with phosalone 35 EC (2 ml./l.), chloropyriphos 20 EC or endosulfan 35 EC have been found to be effective in controlling the pests.

Diseases

The main diseases reported are leaf spot (***Phleopheosporaindica)***, base rot (***Ceratocystisparadoxa***), heart rot (***Phytophthoraparasitica)*** and anthracnose (***Colletotrichumgloeosporioides*)**. Application of Dithane M-45, copper oxychloride (3 g./l.) etc. have been found to be effective.

Lecture 10: APPLE

Botanical Name:	*Malus* × *domestica*
Family:	Rosaceae
Origin:	South West Asia
Type of fruit	Pome
Edible part:	Flesy thalamus
Inflorescence:	Corymb
Chromosome no.:	X=17, 2n=34,51

Apple is the most important temperate fruit of the northwestern Himalayan region in India. It is predominantly grown in Jammu and Kashmir, Himachal Pradesh and hills of Uttar Pradesh, accounting for about 90% of the total production. Its cultivation has also been extended to Arunachal Pradesh, Sikkim, Nagaland, and Meghalaya in north-eastern region and Nilgiri hills in Tamil Nadu.

Climate and Soil

Most of the apple varieties require **1,000-1,500 hours** of chilling **below 7 C** during winter to break the rest period. These conditions are available at an elevation of 1,500 - 2,700 m above mean sea-level in the Himalaya ranges. By and large, the average, the average summer temperature should be around 21 -24 C during active growth period. Low temperature, rains and cloudy weather, during flowering period hamper the bee activity, affecting cross pollination adversely. Inclement weather, particularly low temperature below 15 C during bloom restricts the bee activity which is completely inhibited below 4.4 C, affecting fruit set. Fully opened blossoms may be killed at temperatures below -2.2 C. The optimal temperature for pollen germination and fruit setting is 21.1 - 26.7 C

Well distributed rainfall of 100-125 cm throughout the growing season is most favourable for its optimal growth and fruitfulness. The long drought spells during fruit development and excessive rains and foggy conditions at fruit maturity hamper fruit size and fruit quality.

Soil depth, drainage and pH determine the suitability of soil types. Loamy soils, rich in organic matter having a pH of 5.5-6.5 with gentle to moderate slope, proper drainage and good aeration are most suitable. The soil should be free from hard substrata and waterlogged conditions.

Varieties

In apple there are two types of varieties i.e. diploids and triploids. The diploids usually have plenty of pollen and are self fruitful. The triploids on the contrary are self unfruitful and productive only when they are pollinated by diploid varieties. Most of the commercial apple varieties are diploids. Triploids are rare. Example

Diploids: Red-delicious, Yellow delicious, Jonathan etc.

Triploids: Baldwin, Beauty, Tropical beauty

Recommended varieties of apple in different Indian states

Fruits	J&K	H.P.	U.P.
Apple	Red Fuji, Red Co- Fuji, Benoni, Irish Peach, Cox's Orange Pippin, Ambri, White Dotted Red, American Apirouge, Red Delicious, Golden Delicious, Oregon Spur, Rich- a -Red, Starkrimson, Red Chief, Well Spur, Hardeman, Gala Selection, Spartan, Gloster, Stark Spur, Top Red, Vance Delicious, Gold Spur, Silver Spur, Lal Ambri, Skyline Supreme, Royal Delicious, Vista Bella, Gala Mast, Spartan, Ginger Gold, Early Red One, Law Red Rome, Scarlet Spur, Florina, Scarlet Gala, Summer Queen,	Tydeman's Early, Mollies Delicious, Starkrimson, Starking Delicious, Red Delicious, Rich-a-red, Granny-Smith, Red Spur, Top Red, Red Chief, Oregon Spur, Golden Spur, Michal, Schlomit, Well Spur, Hardeman, Gold Spur, Silver Spur, Vance Delicious, Royal Delicious, Michal	Early Shanburry, Chaubattia Princess, Fanny Benoni, Red Delicious, Starking Delicious, Rymer, Buckingham, Oregon Spur, Rich-a -Red, Starkrimson, Red Chief, Well Spur

Superior apple cultivars identified under various groups for increasing productivity

S. No.	Type	Varieties
1	*Spur type and semi spur*	Red Chief, Red Spur, Ruby Red, Hardi Spur, Sturdee Spur, WellSpur, Super Red Chief, Stark Spur Red, Spur Type Red Delicious, Bright-n-Early, Oregon Spur, Starkrimson.
2	*Colour strains*	Top Red, Hi Red, Vance Delicious, Hardeman
3	*Low chilling*	Tropical Beauty, Schlomith Michal, Maayan. Vered, Tamar, Anna, Naomi
4	*Scab resistant*	Priscilla, Sir Prize, Macfree, Freedom, Coop 12 and Coop 13, Firdous and Shireen are indigenously developed scab resistant cultivars
5	*Varieties of promise*	Fuji, Red Fuji, Gala, Scarlet Gala, Gala Mast, Granny Smith, Breaburn, Jonagold, Empire, Criterion.

6	*Processing cultivars*	Delicious groups, Granny Smith, Liberty, Rome Beauty, York Imperial, Stayman Winesap, Northern Spy, Prima, Priscilla, Sir Prise, Freedom, Redfree, Summer Red, McIntosh, Maharaji, Prima.
7	*Indigenously developed varieties*	Lal Ambri, Sunhari, Firdous, Shireen, Akbar, Chaubatia Princess, Chaubattia Anupam, Chaubattia Agrim, Chaubattia Swarniam, Chaubattia Alanker, Chaubattia Anurag, Ambred, Ambrich, Ambroyal, Ambstarking
8	*Root stocks*	M-7, M-9, M-13, M-26, M-27, MM-106, MM-109, MM-111 and EMLA-106.

Hybrids

Hybridization programme of apple resulted in release of Lal Ambri (Red Delicious x Ambri) and Sunehari (Ambri x Golden Delicious) in Jammu and Kashmir; Chaubattia Princess and Chaubattia Anupam (Early Shan burry x Red Delicious) in Uttar Pradesh hills; and Ambred (Red Delicious x Ambrich (Richared x Ambri) and Ambroyal (Starking Delicious x Ambri) in Himachal Pradesh. Ambrich, Ambroyal and Ambred have not gained popularity among the growers of Himachal Pradesh because of very late maturity and extended harvesting period, whereas high-colouring and early-maturing cultivars are preferred.

Pollinizing varieties

The most important feature of a pollinizing variety is that its flowering should synchronize with the main variety. In addition to this, it should have abundant viable pollen, long duration of flowering, compatibility with main variety, self-fruitfulness, regular bearing besides good commercial value. The most suitable pollinizor cultivars are, **Red Gold, Golden Delicious, Granny smith. Tydeman's Early, McIntosh and Winter Banana**

Lecture 11: PROPAGATION AND ROOTSOCKS IN APPLE

Apples are propagated on seedlings of **crab apple, Malus baccata** which is most commonly used rootstock of apple in India or self-pollinizing varieties, Golden Delicious, McIntosh, Yellows Newton and Northern Spy having good seed viability and seedling growth. The use of clonal root stocks is gaining momentum and now are popularized and being commercialized due to its established superiority for raising uniform plantations, precocity and high productivity.

Tongue grafting is the ideal method of grafting scion cultivar on the rootstock with more than 90% bud take success. "T" budding during monsoon and chip budding during August can also be done for propagating scions with good bud-take success and smooth scion-stock union. It takes one year for raising grafted plants, whereas two in case of budded plants of standard size.

Clonal rootstocks

Malling IXroot stock is popular which was introduced from East Malling research station, England. The size controlling Malling (M) and Malling Merton (MM) series clonal rootstocks were introduced in India at the Regional Horticultural Research Station Mashobra and Temperate Fruit Research Station, Kotkhai, in Himachal Pradesh, Government Hill Fruit Research Station, and Chaubattia in Uttar Pradesh and Fruit Research Station, Shalimar in Jammu and Kashmir during late sixties.

Table. Clonal rootstock for apple

Category	**Rootstock**	**Characteristics**
Ultra dwarf	M27	Result of M13 × M9, Suited for high density planting
Dwarfing	M 9	Evolved as a chance seedling. Short juvenile phase, weak anchorage, suitable for high-density planting in flat and irrigated areas only
Semi-dwarf	M 4, M7 and MM 106	Suitable for high-density plating and well-drained soils; resistant to wooly apple aphid but susceptible to collar rot
Semi-vigorous	MM 111	Tree size is 70% of standard, drought tolerant and resistant to wooly apple aphid
Vigorous	Merton 793	Wooly apple aphid and collar-rot resistant, early-fruiting, recommended for Kumaon hills of Uttar Pradesh

Planting:

In flat and valley areas'planting is done in square and hexagonal system of layout while in slopes contour planting is preferred. Pits of 1 m^3 size are made and kept open for a month and filled with a mixture of 40-50kg of FYM + 500g of Super phosphate + top soil. The soil is allowed to settle for a month. Planting is done late in winter after the danger of frost is over. One

year old plants are planted. The planting distance varies from 7 to 10m under normal system of planting depending on the vigour of the rootstock

TRAINING AND PRUNING:

The plants are trained according to growth habit and vigour of the root stocks**.** In India the apple trees are trained to **modified leader system** with 3-5 main branches and a clear trunk of 1.0 to 1.5m. Some apple trees bear fruit on short crooked growth called spurs. These spurs bear for several years. Such spurs should be pruned to encourage vegetative growth and new spur development in only when they stopped bearing fruits.

Pruning is done when the plants are dormant i.e. in the month of December-January.

Manuring And Fertilization

Application of manures and fertilizers start right from planting of orchard. The First application should be made at the time of filling of pits. The fertilizer dose depends upon the soil fertility, type of soil, kind and age of trees, cultural practices, climate and crop load. The dose of manures and fertilizers should be determined on the basis of soil and leaf analysis.

In an orchard of optimal fertility, N, P and K may be applied in the ratio of 70:35:70/ year age of the tree. The dose should be stabilized (700:350:700 g N: P: K/ tree) after 10 year of age. These applications may be supplemented with farmyard manure @ 10 kg/years age of the tree with the maximum of 100kg. Apple trees prefer N, P and K in the form of calcium ammonium nitrate, super phosphate and muriate of potash respectively. As the crop load is low in an 'off' year, the standard fertilizer dose of NPK may be reduced to 500g, 250g and 400g respectively.

Irrigation

Most of apple orchards in India are situated in rain fed sloppy areas where irrigation facilities are inadequate except in flat valley areas. Apple requires uniform distribution of rainfall throughout the year or needs to be supplemented with irrigation during critical periods. The most critical period of water requirement in apple is from April to August, the peak requirement being after fruit set. In critical summer months, the irrigations can be given at 7-10 days interval and rest at 3-4 weeks interval.

Fruit Drop

Most of commercial varieties experience 3 phases of fruit drop-early drop, June drop and preharvest drop. The early drop considered natural, occurs due to lack of pollination and fruit competition. The June drop is caused by moisture stress and environmental conditions which can be checked by maintaining soil moisture through irrigation or mulching. The preharvest drop cause serious economic losses, as the mature marketable fruits abscise before harvesting due reduction in level of auxins or increase in ethylene levels in fruit. Early-ripening varieties like Tydeman's Early, Red Gold and Pippins experience 40-60% drop, whereas in Delicious group loss occurs to the extent of 15-20% of crop load. Application of NAA (10 ppm) before the expected fruit drop or 20-25 days before harvesting checks the preharvest fruit drop effectively.

Harvesting

Since apple is climacteric fruit, the maturity of fruits does not coincide with ripening. The fruits usually do not attain fully ripe edible quality on the tree while harvesting. The fruits should be

harvested at proper picking maturity to attain proper edible quality at ripening. Picking of immature fruits results in poor quality fruits lacking flavour and taste which shrivel during storage. Over-mature fruits develop soft scald and internal breakdown with poor shelf-life. There are several maturity indices which can be adopted in proper fruit harvesting. The TSS of fruit pulp, ease in separation of fruit from spur, change in ground surface colour from green to pale, change in seed colour to light brown, fruit firmness and days from full bloom to harvest are some reliable maturity indices for apple which can be considered singly or in combination.

All the fruits do not mature evenly on trees depending on the time and number of flower flushes. Thus more than one picking are required. Apple fruits should be picked in such a way that bruising and stem punctures are avoided and pedicel must remain with fruit. Apple should be grasped between index finger, middle finger and thumb, and quick upward twist of wrist will easily pluck the fruit along with pedicel. Picked fruit should be placed softly in the picking bags or baskets. The fruits should be transferred carefully from picking baskets to boxes or baskets be transported to packing houses for grading and pacing.

Yield

A full bearing tree yields from 150-200 kg fruit with productivity of 10 t/ha. The bearing generally commences after 5 years of planting and continues for about 50 years. Several varieties of apple show alternate bearing

Physiological Disorder

Bitter Pit in Apple

This physiological disorder of apple is due to **calcium deficiency**. It is characterized by development of small, dry, brown spot or streaks in the flesh, particularly beneath the skin. Large and immature fruits are more susceptible than others. The incidence of bitter pit usually occurs during storage but in some cases it can also develop at harvest. This disorder has been studied for more than a hundred years and many approaches have been attempted to explain bitter pit development, but no one completely succeeded. The fact that total calcium in the fruit is not able to accurately predict bitter pit incidence has puzzled many scientists for a long time. The high correlation with no predictive accuracy between calcium and bitter pit make the development of this disorder one of the most complex and challenging mechanisms present in plants. Heavy doses of nitrogenous fertilizers, excessive shedding and heavy pruning are reported to favour bitter pit. The fruits of cultivars Northern Spy and Delicious are more prone to this malady. The storage of fruits 32-34^0 F and 85-90% R.H controls bitter pit.

POST HARVEST MANAGEMENT

Precooking

After picking, the fruits should be placed in a cool and ventilated place to remove field heat before packing. Air cooler, cold water sprinkling or fruits washing with water also helps quick removal of field heat. Keeping fruits over-night near the tree basins for cooling down is another practical way to remove field heat. Fruit surface must he free of moisture before grading, wrapping or packing in cartons.

Grading

Apples are graded according to fruit size and fruit appearance or quality. On the basis of fruit size, apples are graded manually in 6 grades. On the basis of fruit colour, shape, quality and

appearance, apple fruits can be graded in 3 or more quality grades. These grades are designated as AAA, AA and A; A, B, C; or extra fancy, fancy class I and fancy class II. For size grading, mechanical graders with washing and waxing facilities are available in India now.

Packaging

Apples are packed in wooden boxes. Size of wooden boxes used in different apple-growing areas of India is different and carry about 10 kg or 20 kg fruits in a box. Corrugated-fibre board (CFB) cartons are also available for packing apples. Such cartons are of 2 types-universal cartons and telescopic tray-pack cartons. The CFB cartons not only save the precious wood and forest wealth but result in very less fruit bruising (3.5%) which fetch good market price.

Storage

Apples have a longer storage life compared to other fruits. However, different varieties have different storability. Deterioration of fruits starts after climacteric stage. However, shelf-life of apples can be prolonged by prolonged by providing optimal storage conditions. The cold storage retards fruit deterioration and reduces decay from pathogens and shriveling from water loss. The recommended storage temperature for apple is -1.1 -0 C which is about 0.8 -1.8 C above the average freezing pint of most apple varieties. The relative humidity of 85-90% should be maintained in cold storages. Most apple varieties can be stored for 4-8 month after harvesting Ambri has the longest storage life.

Lecture 12: Litchi

Botanical Name:	*Litchi Chinesis*
Family:	Sapandaceae
Origin:	China
Type of fruit	Nut
Edible part:	Fleshy Aril
Inflorescence:	Panicle
Chromosome no.:	X=15, 2n=30

Litchi, originally a native of south China, reached India by the end of 17th century. India ranks second in the world next to China in litchi production. Most area falls in north Bihar comprising Muzaffarpur, Vaishali, Samastipur, Begusarai, east and west Champaran and Bhagalpur districts. Litchi is famous for its excellent quality, pleasant favour, juicy pulp (aril) with attractive red color. Although litchi is liked very much as a table fruit, dried and canned litchis are also popular. A highly flavoured squash is also prepared from its fruits. The fruit consists of 60 % juice, 8 % rag, 19 % seed and 13 % skin varying upon variety and climate. Litchi is also an excellent source of vitamin C(40.0-90mg/100g) but it contains insignificant amount of protein (0.8-0.9%) fat (0.3%), pectin(0.43%) and minerals especially calcium, phosphorus and iron (0.7%).

Climate and soil

Generally it flourishes best in a moist atmosphere, having abundant rainfall and free from frost. Its plants grow luxuriantly at 30 C. the maximum temperature during flowering and fruit development varies from 21 C in February to 38 C in June in Bihar.

Humidity is another important factor for litchi. The hot winds in summer cause fruit cracking and subsequently damage the pulp (aril). Sometimes it limits the expansion of litchi cultivation. Wet spring, dry summer and light winter are desirable conditions for fruiting in litchi.

Litchi grows in a variety of soil types. However fairly deep, well drained loam soil rich in organic matter is best suited for its cultivation. Light sandy loam is ideal. High lime content in soil is also beneficial to its trees. If soil is deficient, lime must be added to it. Soils in north Bihar, where best litchi is grown, contain about 30%lime. A sandy loam or clay loam with a pH of 5.5-7.0 and sufficient soil depth is ideal for litchi cultivation.

Varieties

A large number of varieties are grown in different parts of India. Of these, Early Seedless (Early Bedana) , Rose Scented, Dehradun, Gulabi, Calcuttia, Purbi, Kasba, Shahi, Bombai, Late Seedless (Late Bedana), China and Deshi are important.

Shahi, Rose Scented and China are commercial varieties of Muzaffarpur, while Kasba and Purbi are the choicest litchis of the eastern parts in Bihar. Early Bedana and Late Bedana are other important litchi varieties. In Uttar Pradesh, Rose Scented, Dehradun and Calcuttia, and in West Bengal, Bombay Green and Kalyani selection are extensively grown. Muzaffarpur, Dehradun, Seedless and Late Bedana are widely grown varieties in Punjab. An early, non-cracking seedless selection, Swaran Roopa, has been identified for commercial planting in Chhota Nagpur area.

- Swarn Roopa is resistant to fruit cracking
- Shahi is suitable for canning
- Sabour Bedana, and Sabour Madhu are litchi hybrids

Propagation

Litchi is raised both through seed and vegetative means.

Seed propagation

Propagation by seed is not common because the plants raised from seed take 7-12 years to come into bearing. These plants normally do not produce true to type fruits and often produce fruits of inferior quality.

Seeds are used generally to raise seedlings for rootstock purpose or raising hybrid seedlings. They should be sown immediately after extraction from the fruit, as they lose their viability in 4-5 days. If seeds remain in the fruit and fruits are not allowed to dry, they can be kept viable for 3-4 weeks. For germination, seeds soaked in water for 18-20 hours should be placed horizontally about 1.5 cm below the surface of a well drained soil. The growth of seedlings may be improved by the use of mycorrhizal soil.

Vegetative propagation

Litchi can be propagated successfully by cuttings and grafting (splice and inarching). Budding is not commonly practiced. **The most common and the easiest method adopted all over the world is air layering.**

Air layering is also called "marcotting" in china and "gootee" in India. About 2 cm wide ring of bark is removed just below a bud from a healthy and vigorous twig about one year old and 2.5-4.0 cm across. The cut is then surrounded with a mud ball containing sphagnum moss (2 parts of damp moss and 1 part of soil from the foot of old litchi tree is best suited) and wrapped with a polythene sheet. Both ends are tied with fine rope or rubber bands to make it practically air tight. When sufficient roots are formed in about 2 months, the branch is cut below the soil or sphagnum moss and potted in a nursery. July –October is the most appropriate time. After removing the air layers (marcotts) from the mother plant, it is desirable to provide some moist or humid atmosphere by sprinkling water mist for further 2 or 3 weeks. It is necessary to cut back the top of the branch, so as to secure a proper proportion of leaves to root. At least 6 months old marcotted (air layered) plants should be planted in the permanent field preferably in monsoon (rainy season).

IBA (2-10 g/litre of water) is the most effective in root promotion in air layering of litchi.

Cultivation

Planting

Before planting, the land should be cleared and levelled with gentle slope on one side of the plot, on the opposite direction of irrigation source. Then pits of 1 m x 1 m x 1 m size should be dug at the desired places a few weeks before the actual planting. These are kept open for 15- 20 days and then refilled with a mixture of well rotted farmyard manure, leaf mould and canal silt. A mixture of farmyard manure (20-25 kg), bone meal (2kg) and sulphate of potash (400g) is also recommended to be mixed with a basket full soil in a pit from a litchi orchard, containing mycorrhizal fungi. It is helpful in establishment and quick growth of newly planted plants. The pits are watered to set this mixture with the earth. Planting is done after a week. Water is applied immediately after planting.

Litchi trees are usually planted square system, 10 m apart. The distance can be reduced to 7.5 m apart each way where litchi plants need protection either from frost or from the desiccating winds.

For quick establishment and less mortality, healthy 6-9 months old, true to type plants, with fine roots should be selected. It is advisable to inoculate all the new plants with mycorrhizal fungi. After planting, the land should not be allowed to dry completely. Hence the new plantation is recommended during early monsoon season.

Training and pruning

Training young litchi plants for making a good framework is necessary. Once the desired shape and a strong framework is achieved, pruning is not required, except removing dead or diseased branches and damaged shoots. In India, this occurs indirectly when a part of the shoot bearing the cluster of fruits is removed during harvesting. However, heavy pruning of tree causes profuse vegetative growth resulting in poor fruiting. If trees become too old and produce small sized fruits, pruning heavily improves the yield and quality of fruits.

Manuring and fertilization

In India, litchi is grown mostly in natural fertile soil. A little of no manure is given. The acute shortage of N, P and K seems to stunt all forms of litchi growth, including floral initiation. The fertilizer schedule recommended for litchi for north Indian plains is given in tables 1 and 2.

Table 1. Fertilizer schedule for litchi in north India

Age of plant	Fertilizers /plant /year (kg)			
	Farmyard manure	Calcium ammonium nitrate	Superphosphate	Muriate of potash
1-3years	10-20	0.3-1.00	0.2-0.6	0.05-0.15
4-6years	25-40	1.0-2.00	0.75-1.25	0.20-0.30
7-10 years	40-50	2.0-3.00	1.50-2.00	0.30-0.50
Above 10 years	60	3.50	2.25	0.60

Table 2. Fertilizer schedule recommended in Bihar

Manure / fertilizer	First year	Increasing amount every year (up to 5-6years)	Fertilizer dose of full bearing tree
Compost	20kg	10kg	60kg
Castor cake	1kg	1/2kg	5kg
Neem cake	1/2kg	1/2kg	3kg
Single superphosphate	2 1/2kg	1/4kg	5kg
Muriate of potash	100g	50kg	0.5kg
Calcium nitrate	-	1/2kg	0.002g

Fertilizer should be applied just after harvesting during the rainy season. If fertilizers are applied late, there is more vegetative growth and less fruiting.

Method of Manuring is similar to that of other fruit crops. The plants grown under deficiency of NPK can flower but do not set fruits. The plants grown under Mg deficiency do not even bloom.

Aftercare

Maintenance of good sanitary conditions is must to keep litchi orchards healthy and disease free. Litchi is a deep rooted tree with most of its feeding roots occurring 20-30 cm deep. Therefore, deep tillage is harmful for its plant since it may cause injury to its roots. Tillage operations should be limited up to upper 7-10cm soil layers, whereas deep tillage up to 15 cm during inactive growth phase is advised.

Since litchi is a slow growing tree taking at least 6years to come to flowering and fruiting, intercropping vegetables, pulses and berseem is advised. Some quick growing fruit plants like phalsa and papaya can also be grown in early years of its plantation. The intercrops should be manured separately and protected from pests and diseases.

Weeds are controlled mainly by hand weeding or hoeing which is very laborious and expensive. Applying pre-emergence herbicides diuron or atrazine @ 2 kg /acre at one month interval keeps weeds under control. Use of black polythene mulch also controls weeds more effectively than organic mulch.

Irrigation

January end to the onset of monsoon is a critical period for irrigation since vegetative growth and fruit development take place. Four months prior to normal floral initiation period (December-January) in northern India, the plants should not be irrigated. Though litchi is a deep rooted, perennial fruit crop, the absorbing roots mostly occur in the upper topmost soil layer between 20 and 30cm depths. Therefore, this zone should have 50% soil moisture during the critical period. Young trees should be irrigated by the basin system. As the tree grows, the basin should be gradually enlarged. The fully grown trees are irrigated by flooding or by furrow irrigation, depending on the availability and source of water as per their requirement. The frequency of irrigation ordinarily depends on soil type. Generally weekly irrigation should be given in summer. No irrigation is required during winter in fruiting trees before fruit set.

Harvesting and post harvest management

The number of days taken by the fruit to mature varies with genotype and environment and hence cannot be the deciding factor for its maturity. Generally litchi fruits, mature 50-60 days after fruit set. The development of color on fruits is a dependable criterion of maturity but it differs from variety to variety. Generally fruits turn deep red when fully ripe. Fruits harvested at this stage possess excellent fruit quality. Maturity of fruit is also determined by the shape of the tubercles which on ripening become somewhat flattened and the epicarp becomes smooth. Litchi fruits, like other fruits, are not harvested individually to avoid skin rupturing at the stem end and quick rotting of fruits. They are harvested in bunches along with a portion of the branch and a few leaves. It prolongs the storage life of fruits. Harvesting of litchi is usually done in May and June. In Bihar, it is done in early June. In India, yield varies from 80-150kg fruits/ tree depending upon variety and tree vigour.

After harvesting, fruits should be packed as quickly as possible, as their quality deteriorates markedly, if they are exposed to sun even for a few hours. In packed litchi fruits, air should circulate freely. The damaged, sun burnt and cracked fruits should be sorted and graded properly. There should be only fruits of one grade in a box. Fruits of different varieties should be packed separately. It is better if the box or container is tagged having name of variety and grade. These are lined with litchi leaves or other soft packing material as paper shavings, wool etc.

To maintain quality and avoid gluts, fruits should be stored properly. Keeping fruits in storage at 5-7 C may minimize the losses. Besides retaining colour and taste, the storage also minimizes the heavy loss in fruit weight. At present almost entire litchi crop in India is consumed fresh. Since litchi is a highly perishable fruit, it's canning and preserving into squashes, jelly and juice is desirable to utilize surplus produce, if any.

The fruits for local market should be harvested at their full ripe stage, while for distant markets they start turning reddish. If marketing of packed fruits is delayed, they should be kept in a cold storage. Litchi fruits can be stored in good condition for 3-4 weeks.

Physiological disorder

Sun burn and skin cracking in developing fruits are two serious problems in litchi. High temperature, low humidity and soil moisture conditions during fruits development promote these disorders.

Inadequate moisture during early period of fruit growth results in the skin becoming hard and sun burnt. It may crack when it is subjected to increased internal pressure as a result of rapid aril growth following irrigation or rain. Fruit cracking in litchi is also favoured if temperature goes above 38`C and relative humidity less than 60%.

Although effective control measures have not been recommended, frequent and adequate irrigation to bearing trees during fruit growth and development period is most useful.

Growth regulators NAA (20mg/ liter of water), GA (40 mg/ liter of water), 2,4-D (10mg/ liter of water), 2, 4,5-T (10 mg/ liter of water) and Ethephon (10 mg/ liter of water) reduce the incidence of fruit cracking. Spraying with Zinc Sulphate (1. 5%) weekly or Calcium Nitrate (1.5%) fortnightly from pea size to harvesting of fruit is an effective method to reduce cracking.

Lecture 13: Papaya (*Carica papaya*)

Family: Caricaceae; 2n= 2x= 18
Origin: Tropical America (Mexico)
Area:133000 ha ; Production: 5639000 MT; Productivity: 42.3 t/ha

Major producing state: Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Madhya Pradesh, West Bengal, Chhatishgarh
Area: Gujarat> AP > MP
Production: AP> Gujarat> Maharashtra
Productivity: TN> AP > Telengana
Fruit type: Berry **Edible portion:** Mesocarp

Uses:

1. Ripe fruits consumed as table fruit while mature unripe one as vegetable
2. Papain (prepared from dried latex of immature fruit) is used for meat tenderizing while cooking
3. Also used for the preparation of chewing gum, dental paste, face-cream etc
4. Increase digestibility of protein due to presence of proteolytic enzyme
5. Processed products- candy, jam jelly, sweets *etc*

Sex forms in papaya
It is a polygamous plant (Dioecious) having many sex forms. However, there are 3 basic sex forms- male, female and hermaphrodite. Female form is stable while male & hermaphrodite form goes to sex reversal under varying climatic condition.

Variety
Pusa Delicious: Gynodioecious (100% productive plants)
Pusa Majesty: Gynodioecious. One of the highest papain yielder
Pusa Giant: Dioecious, tolerant to strong wind
Pusa Dwarf: dwarf statured dioecious plant
Pusa Nanha: Ultra dwarf, suitable for HDP, Kitchen garden, pot and roof garden
CO1: Dwarf dioecious
CO2: semi tall, dioecious. Predominantly cultivated for papain production
CO3: Gynodioecious, tall
CO4: medium tall, dioecious
CO5: Dioecious, cultivated for papain production
CO6: Dioecious, dwarf. Recommended for papain production
CO7: Gynodioecious in nature
Apart from these Coorg Honey Dew, Pink Flesh Sweet, Pant Papaya1,2,3, Sunrise Solo, Taiwan, Red Lady are also some promising papaya cultivars grown under Indian condition.
Soil: Papaya can grow in any type of soil rich in organic matter content with well drainage capacity. But fertile well drained sandy loam soil having pH 5.5-7.0 is ideal for higher yield and productivity of papaya. If the plants remain under water logging/flood for continuous 24 hrs, it causes death of the entire plantation within 3-4 days.
Climate: Planthaving well adaptation and can grow up to an altitude of 2000 m MSL. It bears fruit throughout the year under tropical condition. Under mild subtropical condition it also produce heavy crop of excellent quality. Under too dry and hot summer condition, frequency of male flower production increases many fold resulting barrenness in the plantation. If the temperature goes down very low (<4), it causes considerable damage of the plantation. It is also susceptible to frost injury. Strong wind coupled with low temp. or heavy rains causes destruction of the whole crop. A dry warm sunny climate (21-33°C) is ideal for plant growth and quality fruit production.

Propagation: It is commercially propagated through seed. Seed rate varies from 250-300 g/ha. However, tissue culture/micro propagation technique has very good potentiality for utilizing it at commercial level.

Nursery management: Bed size should be 3m long x 1m wide x 10 cm high. After preparing the bed, it should be treated with 5% formaldehyde- 1 month before sowing to avoid damping off disease infestation. Before the sowing of seeds in the bed, it should be treated with 0.1% ceresan/

thirum dust. Thereafter, sowing should be done at 1 cm deep and 10 cm apart. After that covering the bed with fine compost or leaf mould is essential to get highest germination. Light watering in the morning hours is preferable. Covering nursery bed with polythene sheet/ dry paddy straw is advisable to protect the nursery from adverse weather condition. Seedling will ready transfer to main field within 2 months (15-25 cm high). If damping off disease appears in the nursery, spraying of bordeaux mixture (1%) or copper oxychloride (0.2%) should be done.

Polythene bag sowing: It gives better transplanting success than seed bed sowing. Perforated polythene bags of 22x15 cm size and 150-200 gauge is the ideal container for polythene bag sowing. The container is prepared by filling it with FYM, soil and sand in equal proportion. Thereafter, 4-5 seeds should be sown per container while only one seedling retain per container after germination.

Transplanting of seedlings: When the germinating seedlings starts growing densely, transfer of them to next nursery bed or in pot or polythene bags is essential to avoid overcrowding. It is also done when field is not ready for planting.

Field preparation: Site should be upland having well drainage capacity. Planting of wind break in open and high lying area is essential. Pit of 60x60x60 cm size should be dug out for about 15 days before sowing. Thereafter, filling of pit with top soil along with 20 kg FYM, 1 kg neem cake and 1 kg bonemeal is advisable.

Spacing: Tall and vigorous cultivars- 2 x 2 m; Semi tall: 1.6 x 1.4 m; Dwarf: 1.2 x 1.2 m or 1.5 x 1.5 m

Planting season: In area with mild climate round the year, Feb- March is the ideal time of planting while for frost prone area, June- July is the best time and for area with heavy rain and virus problem in rainy season, Oct- November is the optimum time for planting.

Planting method: Planting is done in the evening hours by lifting the seedlings from nursery bed with ball of earth and planted in the main field. In case of polythene bag sowing- planting should be done just after removal of polythene sheet. For dioecious cultivar, 3 seedling/pit should be planted in triangular pattern while for gynodioecious cultivar, 1 seedling/pit planting followed by light watering should be done.

After care: It is essential to save the seedling against insect pest and heavy rains at early stage. In frost prone area covering the entire field with polythene structure is essential.

Intercropping: Cabbage, cauliflower, radish and legumes are the best intercrop combination for papaya at pre-bearing age. However, Papaya + tobacco intercropping is most remunerative. As papaya is highly susceptible to virual diseases, hence, tomato, brinjal, chilli, okra should be avoided as intercrop in papaya field as they are the host of different viruses. No inter cropping at flowering and fruiting stage is advisable.

Intercultural operations

1. **Weeding:** Weed is one of the most important problems in papaya plantation. Hence management of weed is essential from early stage of their growth. In 1st year- deep hoeing is recommended but once fruiting started hoeing should be avoided as it is shallow rooted crop. Chemical like Fluchloralin, / Alachlore/ Butachlore @ 2kg/ha- 2 MAT control all the weeds for 4 months.
2. **Removal of unwanted plants:** In the plantation of deciduous cultivar, it is necessary to keep upto 10% male plants for proper pollination. Hence, as soon as the plants starts flowering, extra male plants should be uprooted. Weaker and diseased plants should also be uprooted as and when seen in the plantation.

Manuring & fertilization: FYM @ 10 kg/plant + 1 kg oil cake/plant per year in the pit

N- 200-250 g/plant
P- 200-250 g/plant
K- 200-500 g/plant
} in 3 equal splits- starting from onset to end of monsoon

Zn and B deficiency- most frequently observed. Hence, ZnSO4 @ 0.5% and Borax @ 0.1% spary is advisable as and when deficiency is observed.

Irrigation: Low moisture content in the soil causes female sterility while over irrigation results in root rot disease. Water stagnation for even 24 hrs may kill the established plantation. Hence availability of optimum moisture in the field is very essential for better growth and development of papaya plantation. At fruiting stage- irrigation is requited from October to till harvesting in

May @ fortnight interval in winter and at 10 days intervals in summer. Basin system of irrigation is general followed but in low rainfall area- sprinkler/ drip system is economical.

Maturity indices:

1. Milky latex become watery
2. Change of colour- dark green to light green with yellowish ting at the apical end
3. TSS- 7-8%
4. Total sugar- 5-6%
5. Sugar: cid ratio- 50-55
6. Days from full bloom to colour change- 130-135

Yield: On an avg- 60-75 tonnes/ha

Productive life of the plant: 3 years

Papain production: Green, immature fruits are rich source of milky latex containing papain. 2.5-3 months old fruits are ideal for papain extraction.
Season of extraction- rainy season and continue till march
Cool and wet condition- more papain production
Morning hrs to noon – ideal for extraction

Method: 4 longitudinal skin deep incision on the surface of the fruit should be done from fruit stalk end to fruit tip by using sharp blade or stainless steel knife. Depth of incision should not be more than 0.3 cm. Incision should be repeated for 3-4 times at an interval of 4-5 days. After collection of latex, drying of collected latex should be done by sun drying or in electric oven at 40°C.

Lecture 14: Pineapple (*Ananus comosus*)

Family: Bromeliaceae; **2n= 2x= 50**

Origin: Brazil (Parana- Paraguay basin)

Area:313000 ha ; **Production:2498000** MT: ; **Productivity**: 8t/ha

Major producing state: West Bengal, Assam, Tripura, Karnataka, Bihar, Manipur, Meghalaya & Nagaland

Area:Assam>Manipur>ArunachlPradesh

Production:WestBengal>Assam>Tripura

Productivity: Karnataka> West Bengal> Bihar

Nutritional composition: Fruit composed of water (77-91%) and sugar (9.7-12.1%)- together make up over 98% of the fruit.

Uses:

1. Mostly used as table fruit
2. Also used as Processed products (Canned fruit, juice, jam, jelly)
3. Fibre present in the leaf of *A. erectifolius*- used in paper industries
4. Plant & fruit residues is a good source of cattle food
5. Stem and fruit- a good source of protease enzyme (Bromelain) which is used in hydrolizing proteins and peptides

Climate and soil: Pineapple is a crop of humid tropics. The fruit grows well near the sea coast as well as in the interior, so long as the temperatures are not extreme. The optimum temperature for successful cultivation is 22°-32°C. Leaves and roots grow best at 32°C and 29°C respectively. Their growth ceases below 20°C and above 36°C. A high temperature at night is deleterious and a difference of at least 4°C between day and night temperatures is desirable. It can be grown up to 1,100m above mean sea-level, if the area is frost-free. Although optimum annual rainfall for its commercial cultivation is 100-150cm, it grows remarkable well under a wide range of rainfall. In areas where the rainfall is less, supplementary protective irrigations are necessary during dry season.

The plants come up well in any type of soil except heavy clay soil. Sandy loam soils are ideal. The soil should be 45-60 cm in depth without hard pan or stones. In low-lying areas high water table should be avoided. The plants prefer a soil pH of 5.0-6.0.

Varieties

Kew: It is a leading commercial variety valued particularly for canning. Its fruits are big-sized (1.5-2.5kg), oblong and tapering slightly towards the crown. The fruit with broad and shallow eyes becomes yellow when fully ripe. The flesh is light yellow, almost fibreless and very juicy. The leaves often have a short sector of small margin of spines just behind the tip, and irregularly on the base near its attachment to the stem.

Giant Kew: Cultivated in certain regions of West Bengal, it is synonymous to Kew except the size of plant and fruit which are larger than Kew as the name signifies.

Charlotte Rothchild: It is partially cultivated in Kerala and Goa. The fruit is similar in taste and other characters to that of Kew.

Queen: Widely grown in Tripura, and partly in Assam and Meghalaya, its fruits are rich yellow in color, weight 0.9-1.3kg each. The flesh is deep golden-yellow, less juicy than Kew, crisp textured with a pleasant aroma and flavour. Eyes are small and deep, requiring a thicker cut when removing the skin. The leaves are brownish-red, shorter and very spiny.

Mauritius: A mid-season variety of the Queen group, it is grown in some parts of Kerala. Fruits are medium in size, deep yellow and red in colour. Yellow fruits are oblong, fibrous and medium sweet compared with red ones. This is ideal for table purposes.

Jaldhup and Lakhat: These are two indigenous types grown in Assam, both being named after the place of their production. Both are under Queen Group with fruits smaller than Queen. Lakhat is markedly sour in taste, whereas Jaldhup has its sweetness well-blended with acidity. The fruits of Jaldhup again have a characteristic alcoholic flavour of their own and can be easily distinguished from other fruits of the Queen group on the basis of this character alone.

Propagation

The performance of the plant depends on vigour, growth rate, and time taken for bearing, fruit size and quality of planting material. Besides type and size of plant material also results in variation in the performance of plants. If planting material of different types and sizes is used, it results in poor rate of plant establishment, uneven growth of the plants, uneven flowering and harvesting stretched over a long time. Uniform cultural operations cannot be taken up. Ultimately plant-wise operations are to be followed resulting in increased cost of production. In a mixed planting, a few plants flower while others become ready for harvesting, posing problems for getting good uniform ratoon crops also. Therefore, it is always advisable to use uniform-

sized material to monotype. Hence, selection of right type and size of planting material is essential for commercial plantings.
In suckers and slips, larger planting material results in more vigorous plants. Of the types and sizes of propagules tried, slips and suckers weighing about 350 and 450g respectively are ideal for higher yield with better produce.

Cultivation

Planting: Time of planting is dictated by the season in which the first plant crop is required. Planting time is very important for natural flowering period, which differs from region-to-region. By the time of natural flowering, if the plant does not attain the optimum physiological maturity, either it escapes flowering in the next season or if flowering is induced in the same season, the plant, bear very small fruits. Hence, the ideal time of planting is 12-15 months before the peak flowering season under natural conditions, which varies from December to March in different regions. Time of planting also varies from place-to place depending upon the time of onset of the monsoon and the intensity of its precipitation. In Assam, planting should be done during August-October, while in Kerala and Karnataka; the best time of planting is April-June. Delaying in planting as late as September, delays crop at least by 7-9 months. The peak flowering under these conditions comes during January-March. The ideal time for planting in North West Bengal is October-November and June-July for other parts.

System of planting varies according to land and rainfall. There are four planting systems-flat-bed, furrow, contour and trench.
Plant density of pineapple depends on growth of the plant and system of planting. Adoption of low-planting densities has been the major constraint in India, contributing to high cost of production. The plant density of 63,400 plants/ha (22.5cm x 60cm) is ideal for subtropical and mild humid conditions, whereas for hot and humid conditions a plant density of 53,300 plants /ha spaced at 25 cm from plant-to-plant within a row, 60cm from row-to-row and 90 cm from trench-to-trench (25cm x 60cm x 90cm) provides high yield. In rain fed, high fertile and hilly areas in north-eastern stats, a plant density of 43,500 plants/ha spaced at 30cm x 60cm x 90cm is recommended. The yield of 70-105 tons/ha may be obtained under high –density planting does not have much adverse effect on fruit size, quality and canning recovery. Less weed infestation, protection or fruits from sun-burn, increased production of propagules (suckers and slips)/ unit area and non-lodging of plants are added advantages of high-density planting.

Manuring and fertilization
Pineapple is a shallow feeder with high N and K requirement. Since these nutrients are prone to heavy losses in soils, practices relating to time of application and form of fertilizer determine their efficient use.
Application of 12gN /plant for Kew pineapple is ideal to obtain high yield at Bangalore, Chethalli (Karnataka) and Thrissur (Kerala). A dose of N, P_2O_5 and K_2O at 12, 4 and 12g/ plant/year respectively is optimum under Jorhat conditions. No response to P application has been observed. However, in the ratoon crop four gram P_2O_5/plant increases fruit weight and yield. Plants receiving 12 g K_2O plant /crop give higher yield without any adverse effect on fruit quality both under irrigated and rain fed conditions. For medium –fertile soils in West Bengal, N (12-16g), P_2O_5, (2-4g) and K_2O (10-12) /plant are optimum.
It is thus advisable to apply N and K_2O each @ 12/plant. There is no need for P application. However, if the soils are poor in P, 4g P_2O_5 / plant can be applied. The N should be applied in 6 split doses. The first dose of N can be given two months after planting and the last one 12 months after planting. The K should be given in two split doses. Entire P and half of K can be given at the time of planting and the remaining K at 6 months after planting. Application of fertilizer under rain fed conditions should be done when moisture is available.

Interculture

a. **Earthing up:** This is an essential operation in pineapple cultivation aimed at good anchorage to the plants. It involves pushing the soil into the trench from the ridge where trench planting is a common practice. As its roots are very shallow, the plants are eventually lodged especially under flat-bed planting in heavy rainfall areas. Lodging of plants at the time of fruit development results in lopsided growth, uneven development and ripening of fruits. It is more important in ratoon crop as the base of ratoon plants shifts up, crop after crop. High –density planting minimizes its necessity as the plants prop each other preventing lodging.
b. **Weed control:** Weeds could be effectively and economically controlled by application of Diuron (3kg /ha) or a combination of Bromacil + Diuron @ 2kg/ ha each as pre-emergent spray and repeated with half of the dose, 5 months after first application. The quality of each herbicide should be mixed in 1,000 liters of water for a hectare of crop.
c. **Mulching:** It is essential to conserve soil moisture. Though mulching is not a common practice in India, use of dry leaves or straw is in practice in south India.

Harvesting: Done at 75-80% maturity for distance market but at full maturity for local consumption during May- Aug

Maturity indices-

- Lower most eyelets turn orange-yellow & get flattened in the centre
- Bracts become loose and turn brown
- TSS- 12-14%
- 130-135 days after inflorescence emergence

Yield: 40-50 t/ha which can be extended upto 50-60 t/ha. In NE hill region only 8.32 t/ha.

Ratooning: In ratoon crop harvesting is possible in 9-15 months. It is done by following method-

- Desuckerig immediately after harvesting leaving only one suckers on mother plant
- Remove slips also
- Fertilization and earthing up – immediately after desuckering
- In HDP- can be taken successfully for 2-3 years
- In NE region- allow upto 15-20 years resulting poor yield
- Best to renew the plantation in every 5-6 years

Lecture 15: Pomegranate (Punica granatum)

Family: Punicaceae; **Origin**: Iran
2n= 2x= 16/18
Fruit type: Balusta (Modified form of berry)
Edible part: Aril

It is an important and favorite table fruit. To highlight its importance it was chosen as a symbol of the 18th international Horticultural Congress held during 1970, sowing it in a basket.

Uses:

- Commercially grown for its sweet-acidic fruit used for dessert purposes
- Used to prepare cool refreshing drinks
- Having medicinal properties
- Wild pomegranate is too acidic and used as souring gent (anardana)
- Double flowered pomegranate which do not bear fruit, used as ornamental due to their bright red coloured flowers.

Species: The genus *Punica* having 2 species-
Punica granatum- cultivated in tropical and sub-tropical part of the world for its fruits.
Punica protopunica- Grown in wild form

Botany: It grows as a shrub but can be trained on modified leader system as a small tree. Pomegranate is a evergreen as well as deciduous in nature. Shrub trained plants remain smaller than single stemmed trained as tree. It is hardy tree and can live over 40 years. The leaves have small petioles and are oval to lanceolate in shape. The shoots have throns which originate deep from the wood. It bears very beautiful red coloured flowers.
Flowers may be solitary, axillary or appear in clusters on short spurs. The calyx is persistent and tubular with 5-7 petals inserted in calyx. Ovary has many locules. Pomegranate fruits are a modified form of berry which is commonly known as balusta. The edible portion is aril (juicy covering of seed).

Soil and climate: Pomegranate thrives well in semiarid conditions. It can adapt wide range of soil and climateic condition. Deep loam to sandy loam soils are considered ideal. It can tolerate alkaline/saline soils with 9 pH. It can grow in light soils but with assured irrigation. It requires hot and dry summers with cool winters.
It is tolerant to frost and freeze fairly well. Very high temperature in summers and too low in winters encourages fruit cracking. Pomegranate have both types of cultivars i.e. some are deciduous in winter and others are evergreen. The tree requires hot and dry climate for the production of high quality fruits.

Cultivars: Most of the cultivars originated as seedling selections. Some promising cultivars have also been developed through controlled hybridization. The recommended cultivars are area specific. For example-
Alandi and Muskati – for Maharastra; Madhugiri, Basein Seedless and Jyoti – for Karnataka; Dholka – for Gujarat; Jodhpur Red, odhpur White, Jalore Seedless – for Rajasthan, Chawla, Nabha, Country Large Red – for Haryana; Velludu – for Tamil Nadu.
Ganesh: A seedling selection from Alandi made by G.S. Cheema at Pune. Plants bear profusely and regularly. This cultivar revolutionized the pomegranate cultivation in Maharastra.
G137: It is a clonal selection of Ganesh
P23 and P26: Clonal selection from Muskati
Mridula: It is a hybrid between Ganesh × Gul-e-Shah Red
Jyoti: It is a hybrid between Bassein Seedless × Dholka
Ruby: It is a hybrid between Ganesh × Kabul × Yercaud × Gulsha Rose Pink

Propagation: The commercial method of propagation is hard wood cutting. Some workers say that pre-conditioning of shoots during June-July by gardling or etiolation increases the level of root promoting cofactors which helps in rooting in cutting. The maturity of shoots used for cutting plays a great role in the rooting process. For getting healthy and precocious plants, one season old cutting should be prepared during first week of December. The length of cutting should be 20-25 cm. Treat the lower ends of these cutting with 100 ppm IBA solution for 24 hrs

before planting in the nursery for better rooting. After 10 -15 days of planting, the beds may be treated with 5 litres of chloropyriphose solution @ 10 ml/L to one m^2 of the bed. Repeat this treatment 20 days after to control white ants attack.

Planting: It should be planted on square system of planting at a distance of 5 m × 5 m apart. Evergreen cultivars may be planted at 4m × 4m distance. Prepare 1m and 1m deep pits one month prior to planting.
The best time for planting is December – January. The evergreen cultivars should be planted in December.

Training: Plant can be trained as single stemed tree and 2-4 stemed bushes (evergreen). Multi stemed trained plants create problems later on as the stems intermingle with each other.
It should be trained as single stemed to get strong scaffold system. No brance should be allowed to develop from ground level to 30 cm of trunk height. Head back the leader at 1 m height to force the scaffolds to develop. Secelte only 4-5 well placed scaffolds on all sides of the main trunk.
It the plants are trained on multistem system of training, then the plants itself develops a balance scaffold system. Remove only the intermingling branches from the stems. It has been recorded that deciduous cultivars perform better as single stemed trees and evergreen with multistemed system.

Pruning: Do not require annual pruning. The fruit is borne on short spurs as well as in the leaf axil and also at shoot apex. Remove only criss-crossed and dried branches. Some branches may be headed back during December by removing 30% of the growth to encourage fresh growth.

Crop Regulation: It is a precocious bearer. Plants start bearing in the 3rd year of planting. It continues to bear for 30 years. The evergreen cultivars flower throughout the years and bear 3 crops. To obtain good quality of fruits and high yield, it is the pre-requisite to select only one bahar as suited in that particular area/region. Remove the flowers manually for rest of the bahars. Deciduous cultivars only bear Ambe bahar (flowering in April - May). The evergreen flower in Ambe bahar as well as Mrig bahar (July) and Hasta bahar (Oct - Nov).

Irrigation: Apply irrigation just after transplanting the plants in December. Light and frequent irrigation should be given at an interval of 20 to 10 days from January to May and at weekly interval from May to end of July. No irrigation may be given if rains come in. Increase the interval of irrigation after the harvesting of fruits in Aug – Sep. The interval of irrigation at that time may be one month. Deciduous cultivars may not be applied any irrigation during Dec-Jan when leaf fall starts.

Intercropping: Pomegranate has short juvenile period. Plants are also planted closely and remain bushy and spreading in nature. Hence, no intercrop should be grown. When planting distance is more than 4 × 4 m, then intercrop can be grown for the first 2-3 years. Growing of vegetables and pulses should be preferred over rabi crops and fodder crops.

Manuring and fertilization: Pomegranate is a hardy crop, growing successfully in low fertile soils. Its productivity is greatly increased by the application of manures and fertilizers. Application of 10 kg FYM and 75 g ammonium sulphate to 5 year old tree is adequeate whereas application of 50 kg FYM and 3.5 kg oil cake or 1 kg sulphate of ammonium prior to flowering is ideal for healthy growth and fruiting. However, for bearing tree, application of 600-700 g N, 200-250 g P_2O_5 and 200-250 g K_2O/tree/year is optimum.

Harvesting: Being a non-climacteric fruit, it should be harvested at fully ripening stage. The maturity indices for pomegranate are-

- Ready for harvesting around 120-130 days after fruit set.
- Calyx at the distal end of the fruit gets closed on maturity
- Distinct sound of grains cracking inside when slightly pressed from outside
- Skin turns slightly yellow

Yield: Yield starts from 4th year with 20-25 fruits/tree while at maturity is goes up to 100-150 fruits/tree

Physiological disorders:

a. Fruit cracking: Fruit cracking, a serious problem, is more intense under dry condition of the arid zone. It is mainly due to deficiency of boron, calcium and prolong dry spell followed by heavy rains, fluctuation of soil moisture, wide difference between day and night temperature and relative humidity. Mrig bahar crops are more prone to cracking.

It can be managed through maintaining soil moisture and not allowing wide variation in soil moisture depletion, cultivating tolerant varieties like Bedana Bosec, Khog and Jalore Seedless. Spraying of borax @0.1% or $Ca(OH)_2$ on leaves and fruits starting from fruit set, spraying of GA_3 @250 ppm in the month of June can also prevent the cracking problem of pomegranate.

b. Internal breakdown: Disintegration of aril in mature pomegranate is known as internal breakdown or blackning of arils, is a serious disorder of pomegranate. It cannot be identified externally, whereas the arils become soft, light, creamy brown to dark blackish brown and unfit for consumption. It is increasing rapidly in the pomegranate growing pockets in western Maharastra.

The incidence occurs 90 days after anthesis. Its intensity increased if the fruits are left on the tree for more than 140 days. The incidence is more on ambe bahar. It increases with the increase in weight of fruits from 150-200 g to more than 350 g. The TSS, acidity, ascorbic acid, reducing sugars, Ca, P and catalase enzymes are reduced whereas non-reducung sugars, starch, tannin, N, K, Mg, B and enzyme PPO and per oxidase increases in the affected arils as compared to healthy ones.

The exact causes are not known and remedial measures are difficult to advocate. Therefore harvesting of fruits at 120-135 days after fruit set is advisable.

Lecture 16: Ber (Zizyphus mauritiana)

- Botanical name — Zizyphus mauritiana
- Family: — Rhamnaceae
- Origin: — India to South-western Asia
- Type of fruit: — Drupe
- Chromosome no: — X=12, 2n=24, 36, 48
- Edible portion — Pericarp

Ber is one of the ancient and most common fruit of India and indigenous to India. It is growing in semi arid condition in the country. It is cultivated widely for its resistance to grow in drought and other diversified climate and soil condition. The fruits are rich in vitamin C, A and B complex.

Origin and Distribution:

Ber is originated in India to South-western Asia. In India, Ber is being cultivated in Haryana, Punjab, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu state. It is hardy fruit tree and is well to thrive under adverse conditions of salinity, drought and water-logging. It is a commercial crop for arid and semi-arid zones of northern India especially in the states of Rajasthan, Punjab and Haryana because of its high yield potential and excellent economic returns to the growers. It is an ideal fruit for cultivation in the arid and semi-arid zones because of least irrigation requirements in the summer months of May and June when it sheds its leaves and enter into dormancy.

Taxonomy:

Ber belongs to the genus Zizyphus of the family 'Rhamnaceae'. The chromosome of genus Zizyphus 2n=24, 36, 48. In India Zizyphus jujube and Zizyphus mauritiana are most important species. Indian ber (Zizyphus mauritiana) is evergreen with spreading nature. Its inflorescence (auxiliary cymose) appear on new growth shoots. The type of fruit is drupe and edible part is pericarp.

Varierty:

More than 300 varieties of ber has been reported. These have been developed by selection in different regions.

Commercial cultivars in different ber growing states of India are given below State	Early	Mid-season	Late
Haryana	Gola, Safeda, Sandur, Narnaul, Seo, Choncahl	Kaithli, sanaur-5, muria, mahrara	Umran
Maharashtra	Shamber, Badami, Manuki, guli	Mehrun, darokhi, kharki	-
Punjab	Nazuk, Noki, Seo, Rohataki, Gola, Selected safed, Sandhura, Narnaul	Banarasi, dandan, kaithii, sanawe-2, walaiti, thornless	Umran, illichi, pathini, 2G2 2G3
Rajasthan	Gola, Seb, Seo	Jogia, mundia, tikadi	Katha, maharavali, bagawadi
UP	Narma varnasi, Delhi, gola, Banarasi Gola	Banarasi karaka muthiya, muriya, pewandi, meharun	Jogia, aligan
Gujarat	-		Ajmeri, chameli, randeri

Soil: Because of its hardy and taproot system, it can be grown in a wide range of soil including porous and infertile soils unsuitable for major fruits and other crops. It grows well in sandy loam soils with neutral or slightly alkaline reaction. It also grows satisfactorily in saline soils.

Climate: It prefers hot and dry climate for quality fruits and production. It can be grown upto an altitude of 1000 m from MSL. Tree growth, flowering, fruit development and maturity seem to be more or less correlated with temperature and thus vary.

Propagation: Existence of old orchard in India is slightly difficult due to the hard endocarp and requires about three to four weeks to germinate. The germination time can be reduced to one week by cracking the endocarp carefully. The seedlings raised are mainly used as rootstocks. Commercially ber is propagated by budding. The time of budding depends mainly on temperature, humidity and availability of budding material. In dry areas, in-situ budding is highly successful.

Cultivation: A plant spacing of 6mX6m is followed for be under rainfed condition. Monsoon period June-July (in south India) and August-September in north India is preferable period of planting

Planting Time

- The budded ber plants can be planted in February-March and August-September, but the latter season of planting gives a better success.
- The ber plants can also be planted bare-rooted during mid-January to mid-February with equal success. The plants are defoliated before lifting from the nursery.

Training: Unless ber trees are trained, the trees become bushy, unproductive and hinder all intercultural operations. To establish a strong frame work, the tree is trained to a single stem upto a height of 75 to 90 cm in the first year. Later, three to five main branches widely spread at all directions may be encouraged. The same process should be repeated to develop tertiary branches as secondary shoots. Final balancing and correction of frame work should be done in the third year.

Pruning: Pruning keeps the trees productive and improves fruit size, weight and quality. The fruits are borne in the axils of leaves on the young shoots of current season. Therefore, a regular annual pruning in ber is very much necessary to induce a good and healthy growth which will provide the maximum fruit bearing area on the tree. Some thinning out of branches is also necessary to avoid too much crowding which helps in reducing the incidence of pest and disease. The best time for pruning is after the harvest during the hot and dry season or when it sheds its leaves and become dormant. Dry, dead and diseased wood, criss-cross branches and weak crotches are removed at the time of pruning. After the establishment of the frame work, pruning should be continued every year. For optimum yield and good quality fruits, 25% of one year old shoots should be headed back. Drastic thinning and severe pruning should be avoided, which affects the growth of plant and gives poor yield.

Irrigation: Since it has very deep tap root system and xerophytic nature and is very hardy, once gets established, needs little care and irrigation. It prefers dry period during flowering and needs irrigation for November-February for better fruit development.

Manuring:Be is a hardy tree and deep root system.

Application of 10 kg FYM, 100g N, 50 g P_2O_5, and 50 g K_2O during first year and increase as per ratio up to 5 years of age that is 40-50 kg FYM, 500g N. 200-250g p_2o_5 and K_2O each.

Flowering: Time and duration of flowering varies with cultivar and location. Flowering starts from July and extended upto November in different regions of the country. In south India, flowering starts from July and continues to September with major fruit set in august itself. It is cross pollinated crop and prominent pollinating insect agents are honey bees, houseflies and yellow wasp. The fruit set ranges from 6.19 to 8.16%. However, under controlled cross-pollination, it ranges between 26 and 46%. Spraying of GA3, 2,4,5-T is found to improve the fruit set and reduces the fruit drop. Fruit growth of ber followed a double sigmoid curve with three distinct phases i.e. and early phase of 45 days after fruit set (DAFS), middle phase, 45 to 90 DAFS and final phase, 90 DAF to maturity (185 days). The growth patterns of fruits and seeds were similar.

Harvesting: To get quality fruits, fruits should be harvested at correct stage of maturity. Under ripe fruits do not ripen properly and never attain the desired quality. Over-ripe fruits, on other hand, lose their attractive colour and become soft. Such fruits have less storage life and deteriorate in quality. The maturity indices are attainment of full size of a particular cultivar with softening of pulp and development of characteristic yellow or golden yellow colour. Picking is done manually and sorted in different groups as over – ripe fruits, unripe fruits, damaged fruits, etc., the correct matured fruits are graded as per size, i.e. large, medium and small and marked after proper packing.

Yield: 80 to 200 kg per tree from 10 to 20 years old tree. Dropping the ber fruits in waxol six percent solution is observed to be effective in reducing the fruit weight loss and decay loss. The ripening is also delayed by this.

Storage: Treating the fruits with wax emulsion and keeping them in perforated papers and polythene bags with wax emulsion treatment could extend the storage life of ber fruits. Under cold storage of 30C and 85% RH, the fruits could be stored upto 30 days.

Lecture 17: Jackfruit

Jackfruit is popularly known as the poor man's food in the eastern and southern parts of India. A rich source of vitamin A, C, and minerals, it also supplies carbohydrates. Tender jackfruits are popularly used as vegetable. The skin of the fruit and its leaves are excellent cattle feed. Its timber is valued for furniture making since it is rarely attacked by white ants. The latex from the bark contains resin. Pickles and dehydrated leather are its preserved delicacies. Canning of flakes can be done. They can be bottled and served after mixing with honey and sugar. Nectar is prepared from its pulp. The rind, rich in pectin, can be used for making jelly. The flakes, seeds, sterile flowers, skin and core contain calcium pectate 4.6, 1.6, 3.7, 3.2 and 2.1%, respectively. They are considered as good sources of pectin.

Climate and soil

Jack fruit can be grown on a wide variety of soils but it grows well in a rich, deep, alluvial and well drained soil. It can also be grown on open textured or lateritic soil provided sufficient nutrients are available. It is preferred in homesteads, as a shade tree or as a mixed crop. It grows well in a warm, humid climate up to and elevation of 1,500 m. In south India, it performs satisfactorily in arid and warmer plains. However, it cannot tolerate cold and frost.

Varieties

Being a cross pollinated and mostly seed propagated; its innumerable types of fruits differ widely in density of spines, rind, bearing, size, shape, quality and period of maturity. Local selections are named as 'gulabi' (rose scented), 'champa' (favour like that of Magnolia flowers) and 'hazar' (bearing a thousand fruits). There are 2 broad groups in cultivated types soft fleshed and firm fleshed. Rudrakshi has common pumello sized fruits with smooth rind and less spines, whereas Singapore or Ceylon jack, introduced from Ceylon, is highly precocious. Sometimes it produces light off season crop between September and December. Muttam varikka is another important variety producing fruits of 7kg each.

Propagation

Jack fruit is commonly propagated through seeds. Seeds should be sown immediately after extraction since they lose their viability during storage. Soaking seeds in 25 ppm NAA for 24 hours improves their germination and seedling growth. Air layering, grafting (inarching and epicotyl) and budding (forkert, chip and patch) are means of its vegetative propagation. In Konkan, it gives a success of 50-90% through epicotyl grafting performed during April–May, with grafts attaining planting size within a year.

Cultivation

Planting

The plants of jackfruit should be planted in a square system (hexagonal if the soil is less fertile) 12m apart. June-August is ideal time for planting. The tap root system along with plants should not be disturbed while planting. The young plants should be protected from stray goats and cattle. Protective irrigations are necessary initially at 12-15 days intervals depending on soil and climate conditions. The plants should be trained by removing lower branches.

Manuring and fertilization

Its plants need adequate nutrition for regular and good cropping. Apply 80kg farmyard manure to a tree annually along with chemical fertilizers. For obtaining higher productivity, the following fertilizer schedule is recommended

Recommended fertilizer schedule for jackfruit

Nutrient	Age of plant		
	1-3 years	4-7 years	7 and above
Nitrogen	200	400	600
Phosphate	120	240	300
Potash	60	120	240

Harvesting and post harvest management

Seedlings trees start bearing from seventh to eighth year onwards while the grafted ones from third year, when a few fruits may develop. Singapore variety starts yielding from third year of planting. The tree attains its peak bearing stage in about 15-16 years of planting. At this stage, normally a tree bears up to 250 fruits annually with annual fluctuations in yield. The weight of fruits also varies depending on the type. On an average about 40-50 tons of fruits/ ha could be obtained.

Lecture 18: Production technology of pear (*Pyrus* spp.)

- French pear Or European Pear or Soft pear: *Pyrus communis*
- Oriental pear or Japanese Pear: *Pyrus pyrifolia*
- Family: Rosaceae
- Origin: South-West Asia
- Inflorescence: Corymb
- Type of fruit: Pome
- Chromosome no: 34,51,68
- Italy is the largest producer of pear in the world.

Pear (*Pyrus* spp.) is one of the important fruits of the temperate region of the world, belongs to the family Rosaceae. Pyrus is differentiated from Malus due to the presence of gritt cells. Lenticles are very important in pear fruit. Ancient Greek poet Homer praised it as one of the 'Gifts of God' because it is highly nutritious in nature, having rich source of Carbohydrates as sugars and starch and cellulose and minerals like Calcium, phosphorous and sulpher.. Among temperate fruits, it ranks second, only next to apple in many respect *viz*. global importance, diversity of existence, acreage and production. In India pear cultivation is mainly confined to the temperate Himalayan mountains at 1,700-2,400 m above mean sea level which have ideal conditions to grow a large number of European (*Pyrus* communisL.) and oriental [*P*. pyrifolia (Burm.) Nakai] pears. However, selection and development of low chill pear cultivars had made its cultivation possible in subtropical regions also. And now it is cultivating as a commercial crop under the *tarai* region of Uttar Pradesh, Punjab and Uttrakhand because these area has a typical subtropical climate with cold winters, necessary for meeting chilling requirement and mild temperature, suitable for flowering and better fruit set.

Climatic requirement:

It can be grown on a wide range of climatic conditions, as it can tolerate as low as -26^{O}C temperature when dormant and as high as 45^{O}C during growing period. A large no. of pear cultivars requires a temperature of below 7^{O}C for 1,200 hours during winter to complete their

chilling requirement to flower and fruit satisfactorily. But a large number of low chill pear cultivars are grown under subtropical plains which require very low chilling temperature of less than 700 hours. Cultivar Patharnakh fruits heavily even at 150 chilling hours and can withstand high temperatures and hot winds during the summers. Apart from this, other cultivars like Kieffer, Baggugosha, Patharnakh, Le Conte, Gola, Pineapple Hood, China pear also performs well in subtropical *tarai* condition with mild winters. But one of the major limitations of pear production is the spring frost, which may kill the blossoms completely and will make the orchard unproductive. Hence, proper air circulation is necessary in the vicinity of a pear orchard, which can achieve by avoiding low lands as well as hail prone localities. The land for pear cultivation must be slightly higher level than the surrounding area and land should be selected on northern aspect.

Soils

Pear can grows on a wide variety of soils but deep, well drained, fertile, medium textured and relatively more clayey soil with pH around 6.0-7.5 is the best for its successful cultivation. Apart from these it can withstand easily in the wet soil and even in the waterlogged condition. But the trees are short lived on sandy and loam soils. Soil depth of 180cm is ideal for proper root development and heavy fruit production. Plant grown in the deeper soil gives much higher yield as compared to the shallow soils.

Flowering

The type of inflorescence in pear is Corymb. Flowers are white, 3 cm or more across, 4-12 together on slender pedicles, appearing with the first foliage. The flowering starts in the last week of February and continues upto third week of march. The fruits are borne on spurs. It is pollinated through insects.

Varieties: Most of the pear varieties are **self unfruitful** and require pollenizers.The following varieties are recommended basing on the results after adopting large no.of trials. They are: Baghu Gosha, Conference, Early china, Bartlett, Favourite, Hardy, Nashpati, Kieffer, Flemish Beauty, Patharnakh, Punjab Beauty, Punjab Nector, Punjab Gold, LeConte, Kieffer etc.

- Keiffer and Le- Conte, Gola and Patharnakh are Asian type of pears.
- Keiffer and Le- Conte are cross between European and Oriental pear.
- Waite and Magness are pollen sterile cultivars of pear.

Propagation

It is mainly propagated by vegetative means of propagation. T-budding during April-September and tongue grafting during December-January is the commercial method of propagation of pear. Apart from this other methods of propagation generally followed in pear are- *Seed propagation* and *Cuttings.*

Rootstocks

The root stocks generally used are the wild Himalayan pears i.e. Pyrus pashia, P.pyrifolia, P. kashiana. To produce dwarf trees Quince-D root stock is used. Some commercial varieties are not compatible with Quince-C root stock which is also dwarfing. Quince A is a vigorous root stock while as Quince B is a semi vigorous rootstock.

Planting

The layout system depends upon the planting system to be adopted and according to the land topography. Generally, rectangular system is preferred over square system of planting as more number of trees per unit area can easily be accommodated by this system without any adjustment.

Planting is mainly done during December to mid-February when the plants remain in dormant condition. The planting distance depends upon soil fertility, cultivar, rootstock, training system and climate of the region. A planting distance of 6x6m and 8x8m is normally recommended for cultivar Baggugosha and Patharnakh respectively under plain condition. A pit of 1×1×1m size is dug at such places and filled with a mixture of soil and well rotten FYM or compost and 30g Aldrin or BHC dust. After giving proper irrigation a small hole per pit is dug and planting is done in to the holes. Very long roots can be shortened and plant should remain straight in its position when roots are being covered with soil firmly.

During planting, grower should plant pollinizer cultivar as every fourth plant in every fourth row. In addition, placement of two-three bees' colonies per hectare is essential for proper pollination and to obtain higher yield.

Training and pruning

Proper training and pruning is very important in pear for the maintenance of growth and vigor of the plant, proper development of strong framework, optimum spreading of fruiting branches as well to produce bigger size fruits of better quality. Pear trees are normally trained to 'Central Leader' system. On the other hand, pruning is done to make the balance between vegetative and reproductive growth. It bears fruit on two years old spurs and the spurs are continued to bear fruit more than six year. Hence, pruning should be planned in such a manner that one-sixth of the fruiting wood replaced in each year. Winter season is the right time for pruning as the plants undergo dormancy during that time.

Manures and Fertilizers

Nitrogen is the only element required for proper nutrition of pear but P and K is also used for getting satisfactory returns. N at 50-100g, P at 25- 50g and K at 50-100g per tree per year of age should be supplied until 6^{th} year and thereafter the rates should be stabilized. High N content of

pear foliage makes it highly susceptible to psylla and fire blight attack. Phosphorus deficiency occurs under high pH and is exhibited by leaf margin and tip burn, short terminal growth, die back of new growth and failure of fruits to mature normally. On the other hand, K deficiency causes marginal leaf scorching. Hence, proper fertilization in each and every year is of utmost importance in pear orchard. P and K along with farmyard manure (60-100 kg/ tree) should be applied in December while half N should be applied at 3 weeks before flowering and remaining half just after fruit setting.

Aftercare

Basin should be prepared immediately after planting and level of soil around the trunk should be kept slightly higher that the level of the basin to avoid the problem of water logging. First irrigation should be done immediately after planning while second one after 2-3 days and subsequent irrigation should be given according to the requirement of the plant.

To keep the stem straight, plants should be staked properly. Apart from this whitewashing of the trunk is also very important to avoid the problem of sunburning.

Thinning out of unwanted shoot should be removed at frequent interval to avoid the overcrowding into the orchard. Sprouts on the rootstocks and root suckers, which are developed around the tree trunk, should also need to remove at frequent interval. Otherwise, it will create competition for nutrient as well as water.

Spacing and Intercrops

As it is normally planted at a spacing of 6x6 or 8x8, the area in between two plants remains fallow. Hence, these areas can be effectively utilized by planting intercrop in the pear orchard. Gram, toria, sunflower can be grown as intercrop in kharif season while wheat, pea, gram can be planted in rabi season. Moreover, peach can be planted as filler crop in pear orchard. But one thing should be kept in mind during cultivation of intercrop in Pear orchard that these intercrop will not compete with the main crop for nutrient, water and other factors. Hence, additional fertilizers should be applied to the intercrops.

Weed is a very important drawback in pear orchard, which can be controlled either mechanically by hand weeding or hoeing, or chemically by using herbicides. Diuron @ 4kg/ha as pre-emergence in the first fortnight of March and Glyphosate @3lit/ha as post emergence one should be applied when weeds are 15-20 cm in height.

Irrigation

Scanty irrigation affects the colour, composition as well as the quality of the fruit. Hence, proper irrigation is essential. Normally in pear orchard, 75-100 cm irrigation is needed annually,

depending upon the texture of the soil. Irrigation should be done after harvesting i.e. from July-August to till October.

Harvesting

For fresh consumption fruits are harvested at fully mature stage while for distance market it should be harvested when the fruits are mature but still firm and green.

Maturity indices:

1. Lenticels of the fruit turn brown on maturity.
2. Colour of the fruit changes from dark green to light green and yellow at advanced stage of maturity.
3. TSS of the fruit should be 12-13% at maturity.

Fruits should be harvested by giving a gentle twist rather than direct pulling. Generally 2-3 picking at 3-4 days interval is advisable.

Yield

A well managed pear orchard under normally yields around 30-40 tones/ha.

Pest and Disease Management in Pears

Pest	Symptom	Control measure
• Pear Psylla (Psylla pyricola)	1. Honey-dew secreted by the insect results into an accumulation of sooty mould which causes blackening of fruits and foliage. 2. Prevention of fruit bud formation, premature leaf drop, injection of phytotoxins and transmission of pathogens for pear decline	1. Avoid the use of heavy N-fertilizers. 2. Summe pruning of water sprouts and terminal shoots 3. Use of sprinkler irrigation to avoid the accumulation of honey dew
• Aphid	1. Newly emerged leaves are curled and fold along the midrib which in advance stage affects the growth of the terminal shoot and the leaves get scorched and turn black at margin.	1. Spraying Roger @ 1 ml/lit or monocil @ 2ml/lit of water during first week of March at 10 days interval
Disease		
• Fire blight (*Erwinia*	1. Initially it appears as blossom blight and later	1. Adaptation of drip irrigation over sprinkler

amylovora)	spreads to shoots, developing fruits and in advanced stage to almost all parts of tree. Infected blossoms suddenly wilt and the pedicel as well as the tissues become water soaked and turn dark green in colour. Affected parts turn brown, then black and usually remain firmly attached to the tree, giving a fire burnt appearance.	2. Frequent removal of Water sprouts and root suckers 3. Spraying of Bordeaux mixture (8:8:100) + oil (2-3%) at green tip in delayed dormant stage 4. Foliar application of streptomycin (100µg/ml) for 5-12 times, throughout the later spring and early summer starting from blossoming
• Pseudomonas blight (*Pseudomonas syringae*)	1. Black lesions appears on the floral part which gradually enlarge and forms the necrotic patches resulting heavy decline of fruit setting and yield	1. Spraying of Bordeaux mixture during the onset of leaf shedding followed by full leaf shedding stage
• Scab (*Venturia pirina*)	1. Dark velvety patches as well as spots are developed on the leaves, twigs and fruits resulting drop down of leaves and fruits which ultimately hamper the yield as well as the proper growth of the tree in the following season.	1. Pruning off of infected leaves, twigs *etc*. 2. Application of systematic insecticides like Bavistin, Topsin-M *etc* @ 0.2% at regular interval during disease occurrence stage

Lecture 19: PEACH

Botanical Name:	*Prunus persica*
Family:	Rosaceae
Origin:	China
Type of fruit	Drupe
Edible part:	Epicarp & Mesocarp
Inflorescence:	Solitary
Chromosome no.:	X=08, 2n=16

Peach is probably the most adapted temperate fruit to the warmer climate. Besides being cultivated in the temperate climate in the hills, it is also cultivated in the north Indian plains in the states of Punjab, Haryana, Rajasthan and Uttar Pradesh. This area has a subtropical climate. The subtropical peaches come in the market early in season (mid-April), growers can get higher returns due to scarcity of other fresh fruits. Its first commercial crop is obtained within three years of planting which is much earlier than majority of other temperate fruits. Therefore the cultivation of subtropical peaches has expanded at a faster pace.

Climate and soil

Peaches can be grown over a wide range of soils but they thrive best on well-drained loamy soil. They do not flourish on heavy, wet soils. The soil should be free from any hard pan or lime concentration within top two meter. Moderately fertile and deep soils are good. Poorly drained soils are often the cause of failure of peach orchards. On the other hand, too light soils are also not good for peach cultivation, since these soils are low in their nutrient-supplying capacity. They often show deficiency of N, P, Fe and Zn. Peach nematodes also develop quickly in sandy soils, requiring corrective measures more frequently.

Peach trees are more tolerant to warm climate than other stone fruits. Therefore, they can be grown successfully over a wide range of climatic conditions. During winter, peach trees shed their leaves to enter rest. To come out of rest, they need some low temperature; otherwise, their growth and blossoming become erratic and abnormal. Thus, varieties having low chilling

requirements of 250-400 hr can be grown in the sub-mountain regions and plains. It plains it grows at an elevation of 240-450m.

Varieties

Peach is generally self fruitful except the variety J.H Hale, which is male sterile. On the basis of their use, peach cultivars can be grouped into table cultivars and canning cultivars

Table cultivars: Table cultivars should be yellow fleshed, free stone and with a regular bearing habit. Eg. Alexander, Elberta, J.H.Hale, Cardinal etc

Canning cultivars: Canning cultivars should be yellow fleshed, cling stone with a small non-splitting pit, uniform size, devoid of red colour at the pit and should mature uniformly. Eg. Certex, Halford, Fortuna, Crawfords early, Golden bush etc.

Nectarine: Smooth skinned peaches are called nectarines

Cultivars:.Nectarine cultivars are mostly preferred for table purposes. Eg. Nectared, Sun grand, Sunlite, Sun red, Sun rise and sun ripe

The choice of peach varieties for a particular place is governed by adaptability to local soil and climatic conditions. Important peach varieties for subtropical areas are:

Table1. Peach varieties for subtropical climate.

Low hills and plains Punjab	Flordasun, Early Amber, Shan-e –Punjab, Saharanpur, Prabhat, Flordaking, Sharbati Pratap, Flordasun, Shan-e –Punjab, Florda Red, Sun Red (Nectarine), Khurmani, Sharbati, Early Grand

Propagation

- Peach is commercially propagated by grafting and budding. Peach seedlings are generally used as rootstocks, though plum, apricot and almond seedlings can also be used. Some

times Bhemi (P.mira) is also used as rootstock. Since wild species produce more vigorous and hardy seedlings than the cultivated varieties, wild seedlings are preferred as rootstocks.

- Peaches are commercially propagated by tongue grafting and T- budding or ring budding.

Rootstock

- Peach wild seedlings are preferred as rootstocks.
- Peach seedlings are generally used as rootstocks, though plum, apricot and almond seedlings can also be used. Some times Bhemi (P.mira) is also used as rootstock.
- Nemaguard, Yunnan, Nemared and Shalin are nematode resistant rootstocks of peach

Planting

Healthy plants of known should be obtained from a reliable nursery preferably near to the orchard site. They should be planted in January when still dormant. Planting should be done by digging 1m x1m x 1m pits and refilling them with the fertile top soil mixed with 40 kg of well-rotten farmyard manure in a pit. Add 30 kg of Lindane (5% dust) or 5ml of Chlorpyriphos 20 EC mixed in two kg soil to control white ants in each pit. Planting distance should not ordinarily be less then 6m x 6m from row-to-row and plant –to-plant, accommodating 225 plants/ha in square system.

After planting, provide stakes or supports to the plants if needed. Remove dead and diseased portion by careful pruning. Provide adequate protection against summer and winter. Keep examining the young plants and remove stock sprouts and suckers. Do not give fertilizer during the first year.

Training and pruning

Of the conventional training systems modified leader and open centre are usually adopted to train peach trees. If sun light exposure is a limiting factor (hills) vase or open centre system of training

is usually followed. Peaches require heavy and regular pruning because fruiting occurs laterally only on previous season‘s growth which bears only once in its life time.

Manuring and fertilization

Peach requires a higher amount of Nitrogen than other temperate fruits. Non-bearing trees should be given 454g of Nitrogen per tree for every year of age of the tree. The bearing orchard should receive 1100g each of Nitrogen and potash and double this quantity of phosphorous in inorganic form and 15-25 tonnes of FYM per ha. Whole quantity of FYM along with P and K is given during December-January. Half of N should be given in spring before flowering and the remaining half a month later, if irrigation facilities are available.

Thinning of fruits

Peach trees overbear, resulting into small-sized fruits. Therefore, thinning of fruits is quite necessary. It increases fruit size significantly and improves fruit color and quality. About 5% of the flowers should set and develop fruits to full maturity. To obtain large-sized fruits, they should be hand-thinned keeping 10-15 cm distance between the fruits 4-5 weeks before harvesting a particular variety. Proper pruning also helps in the thinning of fruits.

Weed control

Weeds compete with the trees for moisture and nutrients. They can be controlled by manual weeding but it is laborious and costly. Since peach roots are shallow, they are likely to be damaged by continuous ploughing. Therefore, use of herbicides is a good alternative. A pre-emergence application of Diuron @ 2-2.5kg/ ha or post-emergence application of Glyphosate @1.5 liter/ha in 500 liters of water during February-March effectively controls broad-leaved weeds and annual grasses in young orchards.

Irrigation

Irrigation of peaches is particularly necessary during hot and dry summer (April-June). This season coincides with the rapid vegetative growth and fruit size also increases at a faster rate in

peaches culminating into a high demand for water. Any shortage of moisture at this stage may lead to fruit drop, reduced fruit size and poor quality. Therefore, it is essential to irrigate peach orchards at 3-4 days intervals in summer in light soils and after a week in heavy soils. Irrigation should be stopped a week or so before harvesting a particular variety.

Harvest and postharvest management

The optimal use of peach fruit varies with the purpose or its use. If peaches are to be marketed in the nearby place, they may be allowed to ripe on trees. For shipping to longer distances, peaches should be picked at the firm ripe stage and pre-cooled in cold running water for a short period to remove the field heat and to retard the ripening process.

As fruits mature, the ground color changes from green to yellow in yellow-fleshed peach Partap, Floridasun and Shan-e-Punjab. Development of red blush on fruit surface facing the sun is also evident. The white fleshed cultivars Khurmani, Sharbati and Prabhat develop creamy ground on their maturity. The TSS increases, acidity decreases and TSS: acid ratio improves. The maturity of peach fruits should never be tested by pressing the fruits between thumb and fingers as it causes bruising. Early –ripening peach Prabhat, Partap and Flordasun take 60-70 days after fruit set to maturity, 80-90 days mid-ripening peaches varieties and 100-105 days for late varieties. Fruit firmness at the shoulders is also a useful index to judge fruit maturity. The pressure value should range from 8 to 14 ib/2.5 cm2depending upon variety.

All the peach fruits do not mature at one time. It is, therefore, advisable to make 3-4 pickings starting with the largest and best colored fruits. Peach fruits should be graded and then packed in wooden boxed lined with newspapers or some locally available material. Usually three layer packs containing about 10kg fruits are preferred in the Indian market. Peaches can also be packed in two kg ventilated cardboard boxes of 28cm x 20 cm x 5cm size. These boxes packed in ventilated wooden boxed can be sent to market.

Pre-harvest application of calcium nitrate (1.5%) increases storage life of peaches for 6-9 days, reducing weight loss, respiration rate and incidence of diseases during storage. Peach fruits harvested at proper maturity can be stored satisfactorily for two weeks at o`-3.3`C and relative humidity of 80-85%

Lecture 20: Strawberry

Strawberries are adapted to many growing regions in India and commercial production is potentially profitable. Strawberries require a fairly long-term commitment. Commercial plantings are normally replaced at least every 4 years.

Strawberry is one of the important small fruit among the berries. Various strawberry species grow wild all over the world, but the cultivated strawberry is based upon two species Fragarin chiloensis and Fragarin verginiana. Hybrid between these two species was the ancestor of all the modern strawberry cultivar. Strawberry has great dietetic value and is one of the potential source of vitamin C and a good antioxidant source. Every 100 gm edible portion contains 89 gm water, 0.07 gm protein, 0.5gm fats, 8.4gm carbohydrates and 59mg ascorbic acid. The strawberry fruit is commercially consumed both in fresh form and can be preserved like Jams, Jellies, and squashes that can be used in off-season. The introduction of day neutral cultivars, fertigation, green house, standardization of agro techniques and improved storage techniques has revolutionized the strawberry industry.

Preparing the Plot, Soil & Climate Requirement

Strawberries perform best when grown in a sunny and sheltered part of the plot and the soil needs to be reasonably fertile and free-draining. To ensure the plants thrive, it's important to prepare the ground about a month before planting. Start by ploughing and raking over the soil to remove any weeds or debris which could otherwise interfere with the growth of crop and can harbour pests and diseases, then incorporation of plenty of well-rotted compost into the earth. Finally, the surface should be raked-over several times to create a fine tilth and levelled land is ready for planting .Strawberries prefer soil reasonably rich in humus because of 70-90 % of its roots found in the top 15 cm of soil. It grows well on soil with pH 5.0-7.5. However, the plant thrives best in slightly acidic soil (pH 5.5-6.5). Soil should be fumigated before planting to control fungal diseases, particularly verticillium wilt. Soil fumigation with a mixture of methyl bromide and chloropicrin helps to increase root system, reduces N fertilizer requirement and control several weeds. The strawberry plants are strongly affected by the environmental parameters like temperature, photoperiod and light intensity. In cold climate, frost as well as winter injury seriously reduce yield of strawberry. Photoperiod has a marked effect on strawberry vegetative growth, plant morphology and yield.

Varieties

Farmers should grow varieties which are resistant to pests and diseases, having adaptability for a desired climate, remain in production for a long period, high yielding and ability to retain size after the 3rd picking, good processing quality and have good runner producing capacity.

Chandler

Fruit is of exceptionally high dessert quality with outstanding colour and flavour. It is very resistant to physical damages caused by rain. Plants are tolerant to viruses. Fruits are large, and the flesh and skin of the fruit is firm with excellent flavour. The fruit is suitable for the purpose of fresh marketing and processing. On an average, berry weights around 15-18 g. The fruits have good TSS value (12%), acidity (0.85%), vitamin C (55.5mg/100g) and sugar content (6.1%).

Tioga

An early –maturing cultivar, it is tolerant to viruses. Fruits are large, and the flesh and skin of the fruit is firm, having good dessert and processing quality. The fruits have TSS 12.2%, acidity 0.98% and sugar 6.2%.Average berry weights about 9g.

Torrey

Tolerant to viruses, it produces numerous runners. Fruits large, flesh and skin medium firm, dessert quality excellent, processing quality good, TSS 12.0%, acidity 0.97% and sugars 6.1%.Average berry weights 6.9g.

Selva

A day-neutral cultivar, it has the capacity to produce off-season fruits. It is different from day-neutral or ever bearing types. fruits large, flesh and skin firm, conic to blocky in shape, dessert quality good. It can be handled and shipped fairly well. Skin bright red, attractive, flesh red, internally somewhat hollow, light in colour at core, average berry weighs 15-18g, TSS 11.1%, acidity 1.0% and sugar 5.5%.

Belrubi

Fruits large, conical (necked fruit), skin bright red, flesh attractive red, somewhat firm, less hollow at core, high quality, sweet, slightly subacid, average berry weight 15 g, TSS 11.8%, acidity 0.98%, sugars 6%.Plant produces adequate runners.

Fern

It is a day-neutral, early-ripening and over-bearing cultivar. Fruits large, medium, conical, solid internally, slightly hollow, skin red, flesh red, firm, flavour excellent, suitable for fresh market and processing. It tastes sweet to slightly sub acid. Average berry weight 20-25g, TSS 11.2%, acidity 0.98% and sugars 6.1%.

Pajaro

It is very successful under summer system. Plant tolerant to virus, Fruit has good dessert and processing quality. Fruit is quite susceptible to physical damage caused by rain. Fruits large flesh very firm, skin firm, red colour, average berry weighs 7.6g, TSS 12.2%, acidity 0.97% and sugars 5.5%.

Few more suitable varieties are Premier, Red Coat, Local, Jeolikot, Dilpasand, Bangalore, Florida 90, Katrain Sweet, Pusa Early Dwarf and Blakemore are also grown.

Propagation

Strawberry is commercially propagated by runners, which is considered as natural vegetative propagation. Generally one plant produces 8-10 runners but under proper management, it can go up to 15 runners/plant, for greater survival and fast growth, the runners should be lifted in September and planted in poly bags using the potting media of 1 soil: 1 Sand: 2 FYM for one month. Propagation can also be done through crowns (3-5 plants/crown), but division of crowns of older plants is too time consuming and labour intensive. Runner formation can be stimulated with the application of IBA (100 ppm) 10 days before flowering, with Morphectin (50ppm) and by GA3 (50-100 ppm) spray. Propagation by seed is not suitable as the seedlings do not come true-to type.

Where there is incidence of viruses and nematodes, mainly in commercial plantation, the growth and production of plants may be reduced to half or even more. For this it is desirable to produce virus-free plants for commercial plantations. In addition, we can also control nematodes by raising them in fumigated soils. Virus and nematode-free planting material provides protection against serious diseases. For large scale propagation of virus-free plants, tissue culture is widely used. Under favourable conditions, one strawberry meristem can be multiplied to yield more than

one million plants in a year. Plants can be regenerated from meristematic callus, anthers and immature embryos.

Training

There are 4 training systems-matted row, spaced row, hill and plastic mulch. Mainly, matted row system is followed in our country.

Matted row

This is the easiest and least expensive method. The runners are usually planted at 90 cm x 45 cm spacing. A spacing of 60 cm x 25 cm for Chandler is optimum. After the initial growth of the first year, runners are allowed to cover the vacant space all around the mother plants .ultimately covering the whole vacant space and giving the appearance of a mat. It is generally followed in heavy soils which are free from weeds. In this system, more number of plants can be accommodated/unit areas which give a higher yield under suitable conditions. The overcrowding may cause higher fruit rot. Therefore, care must be taken to maintain the optimum number of plants without overcrowding.

Spaced row

This system is suitable for cultivars which are average to weak in runner production. The daughter plants are spaced at definite distances by covering the selected tips of runners with soil which become plants. This is done till the desired numbers of daughter plants are obtained for each mother plant.

Hill system

This system is for the cultivars developing a few runners. All runners are removed from the mother plants. The individual plants become large and bear more than those in matted row. The plants are planted 25-30 cm apart in twin rows 20-30 cm apart and 100-110 cm spacing between twin rows.

Plastic mulch:

Black plastic film is used as mulch for the hill system to conserve moisture and control weeds. In this system, berries are kept clean and mould is reduced. The plants bloom earlier. They are less susceptible to damage by frost.

Manuring and fertilization

There are different recommendations for strawberry grown in different states in India. In Himachal Pradesh, applications of 50 tonnes farm yard manure along with 40 kg each of P_2O_5 and K_2O/ha at the time of preparation of beds is recommended. The N (80kg) should be applied in 2 split doses; half in September or after the establishment of plants in September-October, and the remaining half before blooming.

For North hill conditions, apply farm yard manure (25-37.5 tonnes), N (75-100kg), P_2O_5(80-120kg), K_2O (50-80kg)/ha. The farmyard manure should be mixed in soil at the time of preparation of planting bed. Full dose of P_2O_5 and half of K_2O are placed in the planting rows at 15-20 cm depth. Half N should be broadcast in inter-row spaces a month after planting and the remaining half N and K_2O should be side dressed at the time of flowering. Foliar spraying of N (0.5%), P_2O_5 (0.2%) and K_2O (0.5%), 4 times between August and February is also advised.

After care

The flower stems should be removed as they appear on plants after planting. If not removed, flowers create a drain on the plants, reducing their vitality, number and size of daughter plants. This practice also helps establish the plants and aids in tolerating heat and drought. The removal of flower strains from cultivars which produce small number of daughter plants increases the number of runners and plant set. In Hill system, runners should be cut as and when they appear. With matted row system, surplus plants should be removed from outside the rows during late summer or autumn. The operation can be performed normally or with the help of cultivar and other specialized machinery.

Keep the crop weed-free during first season by cultivating, applying herbicides, or plastic mulch. The soil should be worked towards the plants. It should be ensured that soil remains around the crown without covering them. Cultivation should be restricted to only upper 2.54-5.08 cm of the soil. It should be continued till the straw mulch is applied (where it is used). Emergence of weeds during the fruiting season also affects pollination by honey bees, thereby reducing yields drastically.

Irrigation

Irrigation is a must and in humid regions, even short droughts reduce the yield, damaging the shallow root system. Since strawberry is a shallow-rooted plant, the plants require more frequent but less amount of water in each irrigation. Irrigation of newly-planted buds results in increased runner production and early rooting. Strawberry plants produce optimum growth when the soil moisture tension is maintained at less than 1.0 atmosphere. Excessive irrigation is, however, detrimental which encourages growth of leaves and stolons at the expense of fruits and flowers and also increases the incidence of Botrytis rot.

Irrigation should be applied in furrows between the rows. The alleys are usually cultivated after 2-3 days of irrigations. Care should be taken that water should not wet the leaves and fruits as it may increase the incidence of fungal infection. To obtain better fruit size and quality, it should be irrigated judiciously during harvesting. Nowadays trickle and sprinkler irrigation systems are becoming popular. In trickle irrigation, 30% water and energy are saved. Less disruption of picking schedules, better water supply during winter and less rotting of strawberries and saving in water are added advantages. Sprinkler irrigation is, however, valuable in areas where there may be heat stress (>85C temperature).

Harvesting and Post harvest Management

Strawberries are generally harvested when half to three-fourths of skin develops colour. For distant shipment green or white and still hard berries are harvested. Delaying in picking usually increases the proportion of overripe and rotten berries. The picking duration differs from cultivar-to-cultivar. It is 55, 35 and 32 days for Tioga; 55, 30 and 30 days for Torrey during first, second and third year respectively in Himachal Pradesh. For Haryana, U.P conditions, it is 53 days for Tioga and 43 days for Torrey. Depending upon the weather conditions, picked should be done every second or third day. Ripening is faster is hot weather. Do not leave any ripe or rotted berry in the field. Berries should be picked along with a small stem portion attached. Picking should be done in the morning. It facilitates better shelf-life. Thus a yield of 96.53, 47.52, 52.08, 47.83 and 44.24q/ha from cultivar Tioga, Torrey, Howard 17, Catskill and Blakemore respectively may be taken. However, with proper fertilizer management an average yield of 175-300q/ha may be taken.Some plant growth regulators like GA3 (50ppm) sprayed 4 days after flowering, and Maleic hydrazide (0.1-0.3%) sprayed after flowering increase yield up to 31-41% Morphectin (50ppm) improves the fruit size.

Strawberries are harvested in small trays or basket. They should be kept in a shady place to avoid damage due to excessive heat in the open field. For distant marketing; strawberries should be

precooled at 4˚C within 2hr of harvesting and kept at the same temperature. After precooling, they are shipped in refrigerated vans. Strawberries can be stored in cold storage at 32˚C upto 10 days. Afterwards they lose their fresh bright colour, showing some shrivelling and deterioration in flavour. Strawberry fruit can be frozen for their processed product or as dessert. The strawberries having high flavour and a bright red colour. Olympus, Hood and Shuksan are quite suitable for ice-cream making, whereas those of Midway, Midland, Cardinal, Hood, Red chief and Beauty are ideal for processing.

PHYSIOLOGICAL DISORDER

Albinism is a physiological disorder in strawberry due to lack of fruit colour during ripening. Fruits remain irregularly pink or even totally white and sometimes swollen. They have acid taste and become less form. Albino fruits are often damage during harvesting and are susceptible to Botrytis infection and decay during storage. It is probably caused by certain climatic conditions and extremes in nutrition.

Lecture 21: DATE PALM

(Phoenix dactylifera)

DATE PALM (Phoenix dactylifera) is a highly nutritious fruit. It is rich in sugar, iron, potassium, calcium and nicotinic acid. One kg fully ripe fresh ripe fresh dates provide approximately 3,150 calories. The flesh of dates contains 20% moisture, 50-65 % sugar, 2.5 %fibre, 2 % protein and less than 2% each of fat, minerals and pectic substances.

Thus, date fruit can help supplement the dietary needs of desert people where very few nutritive foods are available. In California, diced date, date paste and sugar are manufactured for use in breakfast and bakery. The leaves of the palm also have potential for use in the manufacture of paper.

Climate and soil

Date palm is very exacting in its climatic requirement, which according to an Arab saying should grow with its feet in running water and its head in the fire of the sky. The successful cultivation of date palm requires a long summer with high day as well as night temperature, a mild winter without frost, and absence of rain at the time of flowering and fruit setting with low relative humidity and plenty of sunshine. It is estimated that finest date varieties require 3,300units of heat (base 10`C) for full maturity of its berries.

Fruits on tree

The heat unit summation must occur from pollination until full maturity of berries. This period should be rainless and dry. This is in contrast to its native home in Mediterranean region where summers are dry with rainy winters to allow fruit development from May through September –October. In Indian subtropics, fruiting period is confined only from February-July whereas ripening period coincides with rainfall. Therefore, fruits do not reach ripening stage and should be harvested at earlier stage of fruit development.

Deep, sandy loam soils ideal for maximum water–holding capacity and good drainage are desirable. Date palm can grow in alkaline and saline soils but in such soils its growth and productivity are greatly reduced. The soil profile should be free from stones of calcium carbonate concretions and hard pan at least up to 2 m depth. Date palm tolerate high soil salinity (pH 8-10). It can survive in soils having 4 % salt concentration, provided the root system does not come in contact with a stratum of soil where the sodicity is more than !%.

Varieties

More than 1,000 varieties of dates are known to exist. However, only a few of them are commercially cultivated in different countries. Halawy, Khadrawy, Sayer, Barhee and Zahidi in Iraq; Deglet Noor, Medjool and Ghars in North African countries and Begam Jangi and Dhakki in Pakistan are commercial cultivars. Of the date varieties evaluated, Barhee, Halawy, Khalas and Khaunezi have a very little or no astringency and are thus suitable for eating as raw. These varieties can be harvested and used at doka stage before the onset of rains. Date palm Medjool,

Zahidi, Shamran and Khadrawy are astringent at doka stage and can be used for processing to prepare dry dates (chhuhara) and soft dates (pind khajoor). The red colored dates Zagloul and Hayani are suitable for the preparation of date juice (RTS) and other products like jam and chutney. The important date varieties are:

Halawy

An early cultivar, suitable for raw eating and processing as soft dates. Tolerant to rain. Fruit small to medium, oblong with rounded apex and yellow at doka stage. TSS 25.5-42.2% and astringency in fruit at doka stage low or almost absent.

Khadarawy

A is comparatively dwarf-and mid-season cultivar. Fruit matures slightly later than Halawy. Small to medium, oblong-ovate and greenish-yellow at doka stage.

Shamran (Sayer)

Mid-season cultivar, slightly tolerant to high humidity. Fruit is medium to large, oblong-oval and yellow at doka stage with faint longitudinal streaks of red near the base.

Medjool

A late-ripening cultivar, it is suitable for preparation of dry dates. The fruit is large and broadly oblong- oval to somewhat ovate, orange-yellow with a fine reddish-brown stippling and highly astringent at doka stage. The seed has ridges.

Barhee

A mid season or late cultivar. Fruit small to medium, ovate to nearly round, golden-yellow and almost free from astringency even at green stage. Hard ripe doka fruits very sweet and suitable for raw eating.

Zahidi

A mid-season and prolific–bearer, variety, slightly tolerant to rain or high humidity because of smooth and hard surface. Fruit small to medium, ovate and yellow, astringent at doka stage. Fruits are suitable to prepare soft dates.

Khalas

It is a mid-season cultivar. Fruit small to medium, oblong oval, yellow and sweet at doka stage, has an oblique base and irregular outline. It is suitable for raw eating and for processing as soft dates.

Wild date palm (Phoenix sylvestris):

This grows wild in the mid hill region of the North West Himalayas and is a very multipurpose tree. It has been described under the chapter "Wild date palm".

Propagation

Date palm is propagated by off- shoots (suckers) emerging from the base of the palm. Since plants raised form seeds not only bear inferior quality fruits but almost half of them may be non-bearing males. The off shoots could be separated from mother plants 4-5 years after planting. Thus, 8-20 off shoots of 8-15 kg size can be obtained during its fourth and tenth year of life and none therefore. This is obviously a slow rate of multiplication. Absence of a fast multiplication technique for date palm is thus a prominent bottleneck in its extension of area. About 30 million offshoots are required to cover 0.3 million ha area in the arid north-west region. Although, tissue-culture technique has been standardized in date palm, its commercial use is still constrained owing to variation.

Prior to the removal of offshoots, the outer leaves are cut back to two thirds of their lengths and the inner leaves to half. The stalks of the pruned old leaves are tied together to protect the tender apical growing bud. It is ensured that offshoots have well –developed root system. The offshoot separated by cutting the connection with the help of a sharp chisel in such a way that no injury is caused to the mother palm. The copper fungicidal paste should be applied to cut end of the off shoot.

Research is in progress to induce rooting to establish small sized off shoots and to induce more number of off shoots/ palm. Application of IBA to small offshoots before removal from mother palm and then putting them in mist is quite effective in footing and survival percentage. The other vegetative them methods- cutting, grafting, budding and layering are not successful.

Cultivation

Planting

Date palm is a perennial tree and bears fruits for 40-50 years. Therefore, adequate planting distance is very essential. In general, planting is done at 8 m distance between rows and plants in square system, which facilitates intercultural operations and proper development of the palms. A total of 156 palms are accommodated in one hectare. Since it is dioecious, 10% of these must be raised by planting male offshoots to provide adequate pollen-grains.

The field should be thoroughly ploughed, leveled and pits of 1m x1m x 1m size are dug during simmer. They are kept open for about a fortnight and refilled with a mixture of garden soil and well decomposed farmyard manure. Care should be taken that the crown of the planted offshoots remains at least 10-15 cm higher than the ground level so that the irrigation water does not touch it or enter into it. Young offshoots should be protected against intense heat and low winter temperature for at least 2-3 years by providing partial shade. Rainy season (July-September) is ideal time of planting.

Regulating leaf number

Sufficient number of green leaves is necessary for growth, development, and yield. Insufficient number of leaves results in low quality fruits and lesser inflorescence in the following spring. About 75-100 leaves are in Khadarawy, Zahidi, Barhee, and one to every 8-9 leaves in Halway, Deglet Noor and Dayri. Further, 12 leaves/ bunch is optimum leaf-bunch ratio in Barhee dates. Optimum yield and good quality fruits could be obtained with 8 active leaves /bunch when 5-8 bunches/ plant are retained. The old and senescing leaves should be pruned. Time of leaf pruning is June. It is better than in February. To facilitate pollination and subsequent handling of bunches, the spines from the leaves around bunches are also removed in the late winter to early spring.

Pollination

Date palm is highly cross pollinated due to its dioecious nature. In commercial plantation, mechanical or hand pollination is done. For this, 2-3 male trees are enough to pollinate 100 female palms. About 2-3 strands of male flowers are inserted between the strands of female flowers. Since metaxenia is common in date palm, selection of a good pollenizer is important. The quality of date fruits, particularly fruit size and time of ripening are influenced by pollen. Under Indian conditions, early ripening is desired to avoid losses due to rains. If the male spathes open earlier than female, the pollen is dried and stored for use at a later date. Dried pollen containing about 10% moisture can be stored satisfactorily with calcium chloride at room temperature for 2-3 weeks. It can be stored until the next season in refrigerator at about 4`-5`C. However, fresh pollen produced the best fruiting, followed by that with refrigerated pollen and pollen stored at room temperature. Trailor mounted palm dusters are used in USA. When pollen dust is used, dusting has to be repeated 2-3 times.

In India, spathes generally emerge during February-March and the flower opening starts during March-April. Although stigma of female flower remains receptive for several days, it is better to pollinate the inflorescence as soon as they crack open.

Fruit thinning

Fruit thinning is necessary to ensure adequate flowering in the following year, to improve fruit quality, prevent delayed ripening and reduce compactness and increase ventilation of the bunches. Thinning can be done manually of by chemical sprays. Manual method is common which involves removal of some bunches or strands from each bunch or shortening the length of strands. The number of fruit that a palm can sustain depends on variety, age, vigour and number of green leaves. Three to four bunches/palm is recommended from fifth year onwards. In India 8-10 bunches are left on each palm. The best results are obtained by removing one third strands from the centre of the bunch. However, in long stranded variety, Deglet Noor , shortening of the strands is also necessary.

Plant growth regulator ethephon is an effective fruit thinning agent. It provides additional benefit in inducing early ripening of berries. This is of great significance in India, as harvesting of fruits before the onset of rains is advantageous. Ethrel at 500-1,000ppm encourages early ripening.

Manuring and fertilization

Nutrient application is important for satisfactory production of quality dates. A dose of 30kg N, 20kg P and 50 K/ha should be applied. However, in India, application of 1.36 kg N/tree is necessary. Manures can be applied in the beginning of winter season and the fertilizers in March/ April. However, an adult tree should be fed 600 g N, 100 g P and 70 g K per year. The application of K and P should be monitored according to soil conditions. Application of 12.5 - 35.2 tons/ha of farmyard manure is beneficial.

Intercropping

In areas where irrigation facilities are available, intercrops can bring handsome returns. Preference should be given to lentil, gram, peas and senji in winter and mash, green gram (mung) and black gram for summer. Suitable vegetable crops can also be taken with adequate Manuring. Small- sized fruit trees like pomegranate, phalsa and papaya can also be grown between date palm. However, under such conditions, additional requirements of water and nutrients for the intercrop should be provided.

Irrigation

Irrigation is very essential in date palm because it is grown in hot and dry, low rainfall areas. Further, the water requirement of date palm is high although it can withstand prolonged droughts. Date palm likes wet feet but is damaged under prolonged stagnation. In high water table areas, 4- 6 irrigations in a year may be adequate. Light and frequent irrigations must be given after planting. Mulching may be useful at this stage. In sandy soils, irrigation may be given everyday or on alternate days. The frequent irrigations is reduced after the offshoots have established which is dependent on soil texture and weather conditions.

About 10- 12.5 acre cm of water is required to grow palms where the soil is dry during ripening and 6-8 acre feet where heavy water is continued throughout the year. Mulching with black polythene or available organic mulch materials like date palm leaves or weeds in the basin helps conserve moisture and increase irrigation interval.

Harvesting and postharvest management

The dates are eaten at different stages of maturity depending upon the varieties and thus harvested at different stages according to local demand, customs and climate. In India where maturity coincides with monsoon, fruits are harvested at 'doka' stage to avoid spoilage due to rains and high humidity. Spraying of Ethephon (1,000ppm) at color break stage is recommended in Gujarat to advance maturity. Under Mediterranean climate, they are allowed to ripen fully before harvesting. It is stored after drying. Fruits for fresh eating are preferred at 'Dang' stage but handling of such fruits is difficult.

Date palm trees usually take approximately 6 years for commercial bearing yield is comparatively less during initial years but it increase with age. On an average, 50 kg doka fruits are produced from each palm of 10 years age increasing to 75 kg at the age of 15 years. However, the yield also depends upon variety, cultural practices and other factors.

The dates harvested at doka stage have 70-80 % moisture. They have very poor keeping quality. Therefore, these fruits should be marketed soon or may be cured or processed. Since

Doka or dang fruits cannot be stored for future use, curing should be done. Doka fruits are successfully processed to prepare Chhuhara. The technique involves boiling fruits for 5-10 min. Depending on cultivar and then dehydration, in solar dryers or in air circulating ovens at 48-50 C for 70-95 hr, the doka fruits can also be artificially ripened to bring them to the final stage of maturity by dipping them in boiling water for 20-25 seconds and then dehydration in oven at 38 C-40 C

The date juice and sugar have been successfully utilized as sweetening and flavoring agent in ice cream. Recently attempts have also been made to can date pulp and khalal fruits in 20-40% sugar syrup. A satisfactory pickle is obtained after 6 weeks of pickling green fruits treated with 15 % sodium chloride and 2% acetic acid.

Lecture 22: Almond Production Technology

Scientific name: *Amygdalus communis/Amygdalus dulcis/Prunus dulcis/Prunus amygdalus*
Chromosome no.: 2n=2x=16
Family: Rosaceae
Origin: Central Asia (Asia minor)
Inflorescence: Solitary
Edible portion: Kernel or Cotyledon (Mesocarp and Endocarp)
Type of fruit: Drupe
Type of Incompatibility: Gametophytic

Introduction:

The Almond is one of the most important and favourite temperate nut fruit of the country mostly grown in Jammu and Kashmir and Kinnaur region of Himachal Pradesh. It is a small deciduous tree, growing to 4–10 m tall, with a trunk up to 30 cm diameter.The flowers are white or pale pink with five petals, produced singly or in pairs before the leaves in early spring. The fruit is a drupe with a downy outer coat. The outer covering or exocarp is reduced to a leathery grey-green coat called the hull, which contains inside a hard shell the edible kernel, commonly called a nut in culinary terms. Generally, one kernel is present, but occasionally two. However, in botanical terms, an almond is not a true nut. In botanical parlance, the reticulated hard stony shell is called an endocarp. It is mature in the autumn, 7–8 months after flowering. The fruit of the wild forms contains the glycoside amygdalin, "which becomes transformed into deadly prussic acid (hydrogen cyanide) after crushing, chewing, or any other injury to the seed". However, domesticated almonds are not toxic.

Nutritional Importance

Almonds are the healthiest and most nutritious nuts of all, considered a well-balanced cholesterol free food. A 100g contains 575 calorie, good amount of fibre (12.2g), excellent source of vitamin E (26mg), total fat (949g), monounsaturated fat (31g), total Omega-3 fatty acid (6mg), total Omega-6 fatty acid (12065mg), protein (21g), potassium (670mg), magnesium (268mg), phosphorus (484mg) calcium (265mg) and iron (3.5mg). They have low in saturated fat and contain many other protective nutrients. Calcium and magnesium good for strong bones, vitamin E and compounds called phytochemicals are power house, which may help protect against cardiovascular disease and even cancer, reduce heart attack risk, lower cholesterol had a favourable effect on blood cholesterol levels.

Climate

The selection of site for an almond orchard should have proper soil and air drainage and must be free from hail storm and frost in the spring. It grows well from 750 to 3210 m AMSL. The tenderest stage in almond is blossoming and development of young fruit is shortly after dropping of the husk. The blossoms become more and tenderer on opening. Blossoms with petals exposed but not yet opened are known to withstand cold at -2.2°C, but blossoms at petal fall

stage are killed at 0.55 to -1.1°C. The blossoms can often withstand temperatures from -2.2 to -3.3°C for a short time, but if low temperatures continue for many hours, they get damaged.

Soil

Almonds grow on a wide variety of soils varying from finest valley soils to rocky soils of foothills. However, they grow and produce best crops in deep, well drained soils of light to medium texture. They do not thrive well in heavy or poorly drained soils.

Varieties

There are large numbers of varieties available around the world. But only few varieties dominate the export market due to superior export quality viz., Non Pareil, California Paper Shell, IXL and Merced. In addition to these exotic cultivars, recently four Indian varieties have been released includes 'Shalimar', 'Makhdoom' and 'Waris' shown promise of higher yields of better nut quality.

Varieties suited for cultivation in different areas:

1. Jammu and Kashmir: Makhdoom, Parbat, Waris, Shalimar, Afghanistan Seedling IXL, Joranolo, Merced and Non-Pereil
2. Lowhills and Valley areas of Himachal Pradesh: Drake, Katha, Peerless and Neplus Ultra
3. Dry Temperate Zone: Neplus Ultra and Texas (Mission)
4. High and Midhills: Merced, non-pereil and IXL

Improved hybrids: JK 39, JK 57, Hybrid 29, Hybrid 50, NB 258

Mutant: Supernova

Pollination management

The almond flowers are self-incompatible. Therefore, to obtain a maximum crop of almonds, essentially 100 percent of the flowers must be cross-pollinated.Honey bee is practically the only pollinating insect of economic importance on almonds. The orchards are usually planted with two rows of the main cultivar and one of the pollinizers (33%). In addition, to this, placement of 4-6 beehives is found highly beneficial and can for increase fruit set and yield of almond by 12-15 percent. During flowering, fair weather with daytime temperatures above 12°C is essential to permit flight of honey bees.

Recommended Pollinizers: Ne-Plus-Ultra, Drake and Dhebar, in addition 'IXL', 'Jordanalo', 'Ne-Plus-Ultra' and 'Waris' are recommended as compatible pollinizers.

Rootstocks: Nemaguard, Nemared, and Lovell peach; Marianna 2624 plum; various peach and almond hybrids. Rootstocks can be either seedlings or vegetatively propagated (clonal).

Nemaguard (Peach) (*Prunus persica x Prunus davidiana*): Most widely used rootstock; resistant to root nematodes; compatible; out yields almond-rooted trees; can be affected by crown gall, oat-root fungus, and crown rot.

Lovell (Peach): Moderately tolerant to root knot nematode and tolerance to heavy soils and higher rainfall; oak root fungus, crown rot, and crown gall.

Bitter Almond: Its seedlings are generally preferred in India, are late bearing; tolerates drought as well as soils high in lime and boron. Sensitive to nematodes, crown gall, oakroot fungus, and crown rot.

Marianna (Plum): It is able to tolerate some heavy, wet soils and soils infested with oakroot fungus; resists root knot nematodes and crown gall; incompatible with Nonpareil cultivar.

Marianna 26-24: It is shallow rooted, good vigour, although tends to slightly dwarf trees. Heavy suckering and compatibility problem with almonds.

Peach/almond Hybrids: These are nematode resistant; drought tolerant; high vigour; deep rooting; tolerance to calcareous soils; susceptible to crown and root rot; somewhat susceptible to root fungal infections, crown gall and root knot nematodes.

Nickels Peach Almond Hybrid: Deep rooting with vigorous roots. Excellent anchorage and root formation. Tolerant of a broad range of environmental conditions. Resistance to nematodes.

Titan Peach Almond Hybrid: Excellent anchorage & vigor. Prefers sandy loam. Very large, vigorous trees. Very sensitive to wet soil conditions.

Propagation

For production of quality planting material of almonds with desired size of seedling rootstocks, nuts from freshly harvested dried bitter almonds are preferred. Stratify seeds by keeping in moist sand during winter season (November - March) at the coolest shady place to release seed dormancy. The seedlings are ready for budding during the month of July to 1st week of August. For dry areas, seedlings of almond and apricot are more suitable while for irrigated lands peach seedlings like Lovell, Halford, Nemaguard and Nemared are found good, which are extensively used as rootstocks in commercial cultivation of almonds at California.

Budding and Grafting: Scion woods of required almonds are budded/ grafted on to seedling rootstocks of pencil size thickness (1-11/2 yrs old) in July, when sap flow in the rootstock and bud wood is ideal. The ideal method of budding is **'T' or shield budding** 10 cm above the ground. The grafting is done in the month of March **Tongue grafting**method.

Orchard Planning and Plantation The budded plants should be planted by square or hexagonal system at a distance of either 6X6m (normal farmers planting system), 4.0x 4.0m (Medium high density system), and 3.5 X 3.5-2.5m (under high density planting system) depending upon the soil fertility, vigour of the tree and availability of irrigation. Every third row should be pollinizer

row. Before planting, pits of 3x3x3ft size should be dig up during the month of September-October. The plants should be planted from February to March in the centre of pit, provided by desired bamboo supports to protect the trees from winds.

Training and Pruning: Modified Central Leader system

At planting time, head back the trees to 1 m above the ground level. Allow the first branch at 0.6 m from the ground. The plants should be trained to central modified leader system by retaining 3-4 branches 15-20 cm apart spirally in order to produce a well-balanced tree. The crotch angles of the scaffold limbs should be 45 to 60º. Almonds produce most of their fruit on short spurs which remain fruitful for about 5 years. Pruning programme should be planned in such a manner that 1/5th of fruiting wood are replaced each year. Thin out very little of the smaller wood, except to remove unwanted water sprouts or suckers.

Water management

For achieving better yields and plump kernels the trees should be given 3-4 irrigations during the dry spell. The critical stages of almond which are most sensitive to water shortages are flowering (Feb to March) and fruit development (April, May and June). Therefore, irrigations must be provided during these stages for getting higher yield of quality nuts. Mulching of tree basins with straw or black polythene further conserve moisture and reduces irrigation intervals. Annual water requirement of almonds is about 300-400 mm. Its rooting depth is 2 to 2.5 m; allows soil water depletion to 30 % and depth of water application is 75-80 mm.

Harvesting

Maturity indices: hull colour changes from green to yellowish with cracks or splitting at suture starting from pedicel end. The seed coat turns brown during the drying-out process of maturation. Under premature harvest conditions, the hulls remain as stick-tights and it requires more energy to dislodge the nuts, resulting in damage to limbs in the form of wounds. Nuts should be placed at a shady place for drying and removing of hulls.

Postharvest Handling

Fruits may be dried and hulled immediately, or stockpiled for fumigation against Navel Orangeworm after harvest. Nuts are dried by forced hot air until their moisture content reaches 5-7%. Nuts are then dehulled and shelled. In-shell nuts can be stored in bins for weeks or months until final processing. Nuts are then shelled and sorted for size and appearance. Last, nuts are bleached for color improvement, then salted, roasted, and/or flavored before packaging.

Storage

Almonds can be stored for months either in-shell or shelled if dry, or very long periods when frozen (years). Commercially, nuts for long-term storage are fumigated for navel orange worm and kept at temps below 4.5ºC.

Insect Pests and Diseases

Leaf curling aphid: Nymphs and adults suck sap from leaves, petioles, blossoms causing curling of leaves, blossoms wither and drop. Spray at bud burst stage with Chloropyriphos (0.02%) or Thiometon (0.05%) or Methyldameton (0.025%) and Dimethoate (0.04%)Repeat the spray after 10 days of petal fall using malathion (0.03%) & endosulfan (0.04%) besides above pesticides.

Sanjose scale: It attacks all above ground parts; foliage turns thin and yellow speckled; bark around scale is reddened and fruits with grey patches surrounded by inflamed red area. Spray diesel oil Emulsion in Potash based Fish oil soap (1:7) or tree spray oil during dormancy when temperature is above 40c during night.

Chaffer beetle: Adult beetle feeds on leaves, buds, blossoms & fruit lets. The grub feeds on roots & causes wilting of plants.

Stem borer: The beetles damage stem and branches drilling big holes in the trunk & branches. Saw dust is noticed coming out from holes. Clean the holes of saw dust and plug these with cotton soaked in petrol after inserting naphthalene balls in holes & watch for any further damage. Repeat the practices.

Shot hole/pin hole borer: Adult and grubs tunned into wood of the plant making pin type holes & galleries. Small holes are sometimes indicated by boring on the bark.

Leaf spot/ shot hole: On leaves, twigs and fruits it causes small round to irregular, light brown to dark brown lesions. Early infected fruits exude gum from the infected sites. Spray plants with copper oxychloride 50wp (0.3%) or Mancozeb 75 WP (0.25%) or captan 50 WP (0.25%) or carbendanzim 50 WP (0.05%) at bud burst, petal fall, fruit let and 10-15 days after fruit let stage.

Almond blight: The fungus attacks current season shoots by gaining entry through leaf blade/petiole and ultimately into bark and wood forming dead, lighted, brown lesions on young bark and wood.

Blossom blight: The fungus invades sprouting buds in early spring and kills terminal twigs along with buds, flowers and young fruits under prolonged wet weather conditions.

Disorder

Gummosis: Resistant cultivars; Kathi and Sloh

Lecture 23: Production technology of Walnut

Scientific name: *Juglans regia*
Common name: Jovis Glans (Jupiter's acorn or nut of the Gods).
Chromosome no.: 2n=2x=32
Family: Juglandaceae
Origin: Iran
Inflorescence: Catkins
Edible portion: Kernel
Type of fruit: Nut (Modified berry)
Type of Dichogamy: Protandary

Introduction

Walnut is an important nut fruit grown in temperate climate. The Fruit became known as the Persian walnut possibly because of its extensive use by Persia (now Iran) for bartering with neighbouring countries. In India walnut is grown in Jammu and Kashmir, Hills of Uttar Pradesh and Himachal Pradesh.

Climate

Persian walnuts are best adapted to Mediterranean climates, with dry, hot summers and mild winters. Walnut trees don't like frosts from mid to late spring (flowering period), nor do they like the temperature to get too hot in summer. Walnuts thrive best in cool winters and dry summers with well distributed rains from March to July. Temperature above 38°C during summers coupled with low humidity results in the scorching of nuts. Rain or high humidity during spring to late summer increases the incidence of blight in walnut. They can withstand -30°C and colder during the middle of winter, but a cold spell of -20ºC in March could cause serious dieback. Late spring frosts in April or early May of -3ºC could cause tip die back and seriously reduce the crop which form inside the tip buds. Persistently lower summer temperatures are not favourable for proper filling of nuts. In the absence of adequate chilling the bud opening and blossoming are irregular and delayed, resulting into poor crop and dieback for shoots. The chilling hour's requirement varies with the cultivars as 700 to 1500 hours are needed for 'Payne' and 'Franquette' cultivars, respectively, cultivars grafted on seedlings, can tolerate high temperature and very low humidity better than any other temperate fruit. It can withstand for a longer period in dry summers and are usually not irrigated because the water is used for other more profitable crops.

Soils

Most productive walnut orchards are found on deep, well-drained, loamy soils. Because in these soils root goes deep, due to absence of compact subsoil layers which restrict root development. These soils include sandy loams, loams, silt loams, clay loams, and silty clay loams; provides ideal soil conditions and roots can grow upto 10ft or more due to good permeability, available of soil moisture is high, and aeration is adequate to favour optimum development of roots and tree growth.

Rootstocks

Walnuts generally propagated on seedling rootstock raised from open pollinated seeds. In Asia, *Juglans regia* (English walnut) seedlings are suitable for use as rootstock. *Juglans hindsii* (Californian Black Walnut) seedlings are good for free-draining soils. *Juglans nigra* (Black Walnut) rootstocks produce slightly less vigorous trees. However, it is susceptible to black line disease, which can rapidly kill a mature tree. In USA, rootstocks like *J. hindsii,* Paradox *(J. hindsii x J. regia*) and Royal (*J. hindsii x J. nigra*) are being used.

Varieties:

1. Jammu and Kashmir: Lake English, Drainovsky and Opex Caulchry
2. Himachal Pradesh: Govind, Eureka, Placentia, Wilson, Franquetfe and Kashmir Budded
3. Uttar Pradesh: Chakrata Selection
4. Selections made in India: Govind, Roopa, and Karan
5. Selections from CITH: CITH Walnut-1 to CITH Walnut-10, Hamdan, Suleiman, Bulbul
6. Others: Chandler, Cisco, Fernette, Hartley, Payne, Serr, Howard

Propagation

Commercial: Patch Budding

In beginning of the 20th century walnut was commercially propagated by seeds. But seedlings produced from seeds are highly heterozygous, that they do not come to type, are highly variable in production and quality of nuts. Seeds are generally harvested from September to early November and dried in open shed. For germination walnut seeds require prolonged moist cold weather before it germinates. Therefore, seed must be sown or stratified to release dormancy factors before spring planting. Maintain moist during stratification period (Dec.- Feb.) and maintain temperature between 1-4ºC. Seeds can also be stratified in refrigerator in small lots. For spring planting of germinated nuts nursery should be carefully prepared.

Vegetative propagation was first time adopted in walnut during 1915 vegetative propagation in California to produce true to type planting material. In walnut, budding and grafting techniques have been standardized. These techniques require rootstocks and budwood/scion wood. The ideal rootstock thickness is about 1.5 – 2 cm, at 15 – 20 cm above the ground level.

Chip budding Suitable time for chip budding is summers, usually in May-June & August; during this period rootstock and scion cultivar must be in fully growing stage so that the bark will slip easily. Chip budding is a technique that may be used whenever mature buds are available. Because the bark does not have to "slip,"

Grafting : Efficient methods for grafting in walnut are wedge and whip methods. The suitable time for walnut grafting is last week of Feb. to mid-March.

Layout and planting

Orchard Layout the walnut orchards in square or quincunx (diamond) design in gentle slope and flat valley. Use contour planting for hilly and steep slope. Space the plants depending on the tree type and vigour. For small and compact tree, use initial spacing of 5 m x 5 m and adjust this to 10 m x 10 m at maturity (high density planting). For highly fruitful lateral-bearing but vigorous cultivars and terminal- bearing vigorous cultivars, maintain an initial spacing of 6 m x 6 m and finally adjust to 12 m x 12 m. Every eight row, a pollinizer variety is planted perpendicular to the usual direction of the wind.

Manure and fertilizers

Manure and fertilizers are generally applied based on leaf nutrient analysis report. In July leaf of the walnut the critical nutrient levels are viz. N (2.2-3.2%), P (0.1-0.3%), K (1.2%), Ca (1.0%), Mg (0.3%), Na (0.1%), Cl (0.3%), B (36-200 ppm), Cu (4 ppm), Mn (20 ppm) and Zn (18 ppm).

Training and pruning

Walnut trees are generally trained after the first year on **'Modified Central leader System'.** After the 1st years' growth, head back to 2 m of its height. Remove all the lateral shoots on the leader, leaving one or two shoots at lower level on the trunk to provide shade on trunk's south and west sides. To avoid narrow crotches, remove all primary buds above 1.5 m from the ground to force secondary buds to grow. Select main scaffold limb 1.6 m above ground. Choose primary scaffold limbs in all directions on the trunk. Ensure that limbs have wider angles, more than 30 cm apart vertically on the main trunk. Remove the rest of the vigorous branches leaving small branches undisturbed for fruiting. Head back all the selected limbs on terminal fruiting cultivars but not for lateral fruiting ones. In the later (after 2-3 years), allow the secondary scaffold limbs

on primary scaffolds to grow by removing the extra vigorous branches. Head back all scaffold limbs every year in terminal fruiting cultivars. For cultivars that are highly fruitful on lateral buds, head back a large number of new shoots on the periphery to reduce fruiting and increase vigorous shoot growth throughout the trees' periphery. On terminal bearing cultivars, head back selected branches and thin out limbs completely.

Pruning is generally practiced in the dormant season but early spring is preferableInitiate selective thinning out of limbs in the top and sides of the tree before overcrowding becomes serious. Do not remove more than 25% of the branch structure at any time. Treat all the cut surfaces with a tree wound dressing such Copper oxychloride or Bordeaux paste.

Irrigation: Sufficient irrigation from April to June is required when there is no rain, continued even after also if rainfall do not occur for plum kernel as well as kernel filling.

Harvesting and post-harvest operation Grafted walnut trees starts bearing after 3 years and full commercial production starts 8-10 years from planting. A fully grown, big size tree produces as high as 100-150 kg nuts but the average yield is 40-60 kg per tree. Crop maturity and harvest from September-October depending on the elevation and cultivars. The nut maturity could be judged by splitting or dehisce of hull. In higher altitude, kernel matures earlier to hull dehiscence while in the lower altitude, hull dehiscence take place prior to kernel maturity. The walnut kernels are mature when the packing tissue between and around the kernel halves has just turned brown (PTB stage) and crop can be harvested if 80% of the nut can be removed with 95% of them hullable. Harvest the remaining nuts few days after the first harvest. Collect the nuts from the ground. Clean, wash, and spread the nuts on a sheet or floor to dry them up to 8% moisture level. Grade the nuts according to size, colour, and variety. Store the nuts in gunny bags in small well-ventilated rooms free from excessive humidity. Nuts have long shelf life and it can be sold in extended marketing season.

Pest and Diseases

Codling moth: Attacks early blooming walnut. Use pheromone traps during May month and spray diazinon or carbaryl (0.2%).

Walnut husk fly: Damage only mid and late season cultivars and weevil feed on kernel causing premature fruit drop. Spray carbaryl (0.2%) twice at 7 days interval.

Walnut blight (*Xanthomonas campestris var. jugalandis*): Infection occurs right from early spring to summer; nut drop, shrivels and discolouration occurs. Rainfall, dew, fog and sprinkler irrigation aggravate. Spray Bordeaux mixture at 10 days interval on opening of first female flower.

Anthracnose (Gnomonia leptostyla): Attacks leaves, young shoots and fruit. Destroy fallen leaves and spray with Zeneb or Captan (0.01%).

Walnut canker or Die back: Swollen or sunken areas of various sizes rapture the bark of branches and trunk. Apply paste of copper oxychloride on diseased portion and foliar spray.

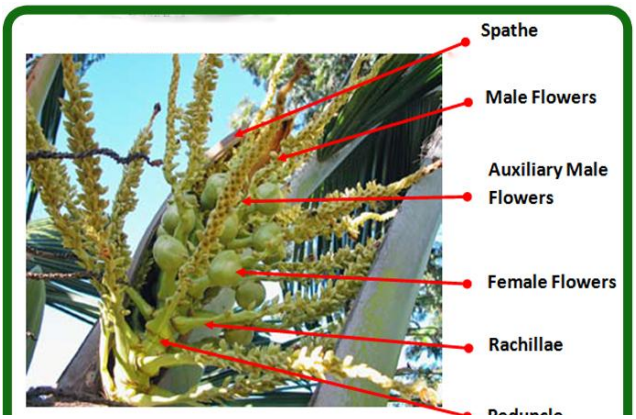
Blackline: Poor terminal growth, die back, drooping leaves, profuse suckering and small holes on the bark at graft union occurs in Persian Walnut. This is due to virus movement from Persian walnut scion to *J. hindisii* or Paradox r/s hypersensitive action occur forming a black line of the infected cells at the graft union. Virus dies at the union and stock remains virus free. It is transmitted by mechanical inoculation, grafting, pollen and nematodes.

Lecture 24: COCONUT

Scientific Name :*Cocos nucifera* L.
Family : Palmae
Origin : South East Asia

Distribution: Coconut is grown in more than 93 countries of the world and Indonesia, Philippines, India are the major producing countries of the world. Coconut is grown in more than 18.95 lakh ha in the country with an estimated 16943 million nuts during 2010-11 with an average productivity of 8937 nuts per ha. Traditional areas of coconut in India are the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Orissa, Goa, West Bengal, Pondicherry, Maharashtra and Islands of Lakshadweep and Andaman and Nicobar. However, several states like Assam, Gujarat, Madhya Pradesh, Bihar, Tripura, Manipur, Nagaland and Arunachal Pradesh have emerged as non-traditional areas for the cultivation of coconut. As per 2013-14 statistics from Coconut Development Board of Government of India, four southern states combined account for almost 92% of the total production in the country: Tamil Nadu (31.93%), Kerala (27.54%), Karnataka (23.26%), and Andhra Pradesh (8.43%). Other states, such as Goa, Maharashtra, Odisha, West Bengal, and those in the northeast (Tripura and Assam) account for the remaining productions. Though Kerala has the largest number of coconut trees, in terms of production per hectare, Tamil Nadu leads all other states. In Tamil Nadu, Coimbatore and Tirupur regions top the production list.

Plant description: The palm has adventitious roots continually produced from the base of the trunk, which is the swollen part or what is termed 'bole', in tall types and in some dwarf hybrids. The stem is called as trunk. It is unbranched, erect, stout and cylindrical, Inflorescence is spadix and flowers are covered under spathe.The axis of the inflorescence is branched, with the branches bearing sessile flowers, both staminate and pistillate.The palm is monoecious with male and female flowers on the same plant .Pistillate flowers are at about the base of the branches subtended by one or two staminate flowers. Fruit is drupe, having three regions and one seeded. The fruit is developed from a tricarpellary ovary.



Importance and uses: The coconut palm is referred to as 'Kalpavriksha' - the 'tree of heaven" as each and every part of the palm is useful to mankind in one way or other. It provides food, drink, fuel and timber. Apart from the importance of copra and coconut oil which is widely used in the manufacture of soaps, hair oil, cosmetics and other industrial products, its husk is a source of fibre which supports a sizable coir industry. The tender nut supplies coconut water, a popular thirst quencher of health and hygienic value. Virgin coconut oil (VCO), extracted from fresh coconut kernel without any chemical processes is abundant in vitamins, minerals and anti-oxidants, thus making it the 'mother of all oil. Coconut industry in the country is mainly confined to traditional activities such as copra making, oil extraction, coir manufacture & toddy tapping. Coconut products such as virgin coconut oil, desiccated coconut, coconut water based vinegar, coconut water are also made. However, coconut milk based beverages, coconut chips, coconut based handicrafts, shell powder, shell charcoal and shell based activated carbon are manufactured in the country on a limited scale. Neera, coconut water based non-alcoholic health drink is now gaining momentum in many states like Karnataka and Maharashtra. Coir and coir based industry is one of the major segments using coconut by-products mainly the husk. Per 100 gram serving with 354 calories, raw coconut meat supplies a high amount of total fat (33 grams), especially saturated fat (89% of total fat) and carbohydrates (24 grams) (table). Micronutrients in significant content include the dietary minerals, manganese, iron, phosphorus and zinc.

Varieties:

Tall varieties	West Coast Tall,East Coast Tall,Chandrakalpa or ,akshadweep Ordinary (LCT),Phillippines Ordinary (kerachandra),VPM - 3 (Andaman Ordinary),Aliyar Nagar 1 (ALR 1),Aliyar Nagar 2 (ALR 2),TipturTall,KeraSagara (Seychelles),Benavali Green Round (Pratap),Phillipines Tall (Chandrathara),Assam Tall (Kamaroopa),Kalpadhenu, KalpaPratiba,KalpaMitra ,Kerakeralam
Dwarf varieties	Chowghat Orange Dwarf (COD),Chowghat Green Dwarf (CGD),Chowghat Yellow Dwarf (CYD),Gangabandom,Malaysian Dwarf Yellow ,Strait Settlement Dwarf Green,KalpaRaksha

Hybrids	Kerasankara (WCT x COD) ,Chandrasankara (COD x WCT) ,Chandralaksha (LCT x COD) ,Keraganga (WCT x GBGD),Lakshaganga (LCT x GBGD),Anandaganga (ADOT x GBGD) ,Kerasree (WCT x MYD) ,Kerasoubhagya (WCT x SSAT) ,VHC 1 (ECT x MGD),VHC 2 (ECT x MYD) ,VHC 3 (ECT x MOD)Gadavani Ganda (East Coast Tall X Gangabandom) ,KalpaSamrudhi ,KalphaShankara (Chowghat Green Dwarf X West Coast Tall)

Climate: Coconut is essentially a tropical plant but has been found to grow under varying agro climatic conditions. The mean annual temperature for optimum growth and maximum yield is stated to be 27^0C with a diurnal variation of 6^0C to 7^0C and relative humidity more than 60 %. The coconut palm thrives well up to an altitude of 600 m above MSL. The coconut palm thrives well under an evenly distributed annual rainfall ranging from 1000 mm to 3000 mm. However, a well distributed rainfall of about 2000 mm is the ideal rainfall for proper growth and higher yield.

Soil: Coconut is adaptable to a wide range of soil conditions, from light sandy soils to heaviest clays with a pH ranging from 5.2 to 8.0. A well drained, deep, friable, loamy soils is the best for successful coconut cultivation.

Propagation: By Seed. Vigorous seedlings which are one year old, having minimum of six leaves and girth of 10 cm at the collar level should be selected for planting in the main field. Early splitting of leaves in the seedlings could be a criterion for selecting good seedlings. However, 18 - 24 month old seedlings are preferred for planting in water logged areas. Planting the seedlings during May with the onset of pre-monsoon rain is ideal.

Selection of ideal mother palm: Success of a viable coconut plantation starts with the utilization of high quality planting materials. Consequently, extreme care should be taken in choosing seedlings to start a plantation. The important features of superior mother palms are:

1. Palms should have a stout, sturdy, straight and robust stem with closely-spaced leaf scars
2. The age of the palm chosen should preferably be from 15 - 40 years for Tall varieties and 12 - 30 years for Dwarf varieties.
3. Palms should be regular bearers with an annual yield of more than 80-100 nuts per tree per year.
4. Yields should be not less than 100 nuts/palm/annum under irrigated conditions (70-80 nuts/annum under rain-fed conditions). Varieties for copra production should have medium sized nuts (about 1,200 g dry weight/nut) with a round or oblong shape.
5. Varieties for coconut water production should have at least 10 - 15 nuts per bunch with more than 400 ml water per nut.

Selection of seed nut

For raising seedlings, it is important to collect seed nuts of high quality from the selected mother palms. The selected nuts can be stored under dry and cool places for about 3-4 months without deteriorating their viability. The following points should be considered while selecting seed nuts.

1. Only fully matured uniform size nuts of 11-12 months old should be harvested.
2. Nuts should not be damaged while harvesting
3. Seed nuts having irregular shape, size and improper development should be discarded.
4. Selected seed nuts should float on water vertically. The content of copra should be more than 150 g and husk weighing above 100 g..

Planting: In general square system of planting with a spacing of 7.5m x 7.5m is recommended for coconut. This will accommodate 177 palms per hectare. However, spacing of 7.5 to 10 m is practised in various coconut growing regions of the country.

For planting a pit of size 1 x 1 x 1 m is dug and filled with top soil to height of 50 cm. However when the water table is high, planting at the surface or even on mounds may be done with same pit size. Two layers of coconut husk can be arranged at the bottom of the pit before filling up the soil (with concave surface facing up). This will help in conserving the moisture. In lateritic soil, addition of 2 kg of common salt will help in loosening the soil. Vigorous seedlings which are one year old, having minimum of six leaves and girth of 10 cm at the collar level should be selected for planting in the main field. Early splitting of leaves in the seedlings could be a criterion for selecting good seedlings. However, 18 - 24 month old seedlings are preferred for planting in water logged areas. Planting the seedlings during May with the onset of pre-monsoon rain is ideal.

Nursery management:

Nursery can be raised either in open with artificial shade or in gardens where the trees are tall and the ground is not completely shaded.

1. The seed nuts should be sown in long and narrow beds at a spacing of 40 x 30 cm during May-June in 20-25 cm deep trenches. However the length and width of nursery beds should be kept as per ones convenience.
2. The seed nuts with less nut water and seed nuts of dwarf cultivars may be sown horizontally to ensure early germination. Discard nuts in which water has dried.
3. Before sowing it is advisable to dip seed nuts in suspension of Lindane (400 g in 100 litres of water) as an additional precaution against white grub and termites.



Young palms require good care in the early of growth. The transplanted seedling should be shaded and irrigated properly especially during the summer months. Provision of proper drainage is also equally important in areas subject to water logging. The pits should be cleared of weeds periodically. Soil washed down by the rains and covering the collar of the seedlings should also be removed. The pits should be gradually filled up as the seedlings grow.

Manures and Fertilizers: Regular manuring right from the first year of planting is essential for good vegetative growth, early flowering and bearing and sustainable yield of coconut palms. The first application of chemical fertilizers should be done after three months of planting.

Fertilizer recommendation for coconut (g/tree)

	April- May			August -September			Total/ year			
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Compost (Kg)
1st year				100	60	150	100	60	150	6
2nd year	75	40	100	125	80	200	200	120	300	12
3rd year	150	60	200	250	120	400	400	180	600	18
4th year	225	100	300	400	200	600	625	300	900	24
5th year onwards	300	140	400	600	280	800	900	420	1200	30

Rock phosphate is recommended as source of phosphorus in lateritic and acidic soils. Fertilisers may be applied in two split doses during April -May and September-October for the rain fed palms and in four or more equal splits for irrigated palms avoiding the heavy rainfall period. In sandy soils with acidic nature, in addition to these fertilizers, 1 kg of dolomite may be broadcast during April-May in the basins and incorporated into the soil by forking.

Irrigation: Coconut responds well to summer irrigation i.e. summer irrigation @ 40 litres per palm per week will increase the yield of nuts by 50%. Under basin irrigation, 200 litres per palm once in four days will be beneficial. In areas where water is scarce drip irrigation system can be adopted. The quantity of water recommended for drip irrigation in coconut is 66 per cent of the open pan evaporation.

Interculture: Tillage operations like digging, ploughing, forming small mounds during August - September and spreading them in December - January, making shallow basins with a radius of 2m before the onset of monsoon and filling it up at the close of monsoon are beneficial to the trees. Regular inter cultivation needs to be adopted to keep weeds under control.

Inter and mixed cropping

In pure coconut garden when palms are spacing at 7.5 x 7.5 as much as 75% of the available area is not effective utilized. Besides, a pure coconut grooves utilize only half of the available light. Hence, a variety of intercrops like pineapple, banana, guava, groundnut, chillies, turmeric and tapioca can be raised in coconut gardens after the palm attaining the height of 5-6 m. In older plantations cocoa, pepper, cinnamon, clove and nutmeg can be grown as mixed crop in places where rainfall is not well distributed, irrigation may be necessary during summer months.

Harvesting: Coconuts become mature in about 12 months after the opening of the spathe. It is the ripe coconut which is the source of major coconut products. Nuts which are eleven months old give fibre of good quality and can be harvested in the tracts where green husks are required for the manufacture of coir fibre. Economic life of the coconut palm is about 60 years.

Yield: Depending upon varieties and cultural practices nut yield may vary from 75 to 150 nuts/year /palm.

Plant protection measure:

Pests:

Rhinoceros beetle: *Oryctes rhinoceros:*The adult beetle bores into the unopened fronds and spathes. Damage by the pest leads to 10 to 15% loss in yield. During peak period of population build up, the adult beetle may be extracted from the palm crown using GI hooks.

Control: Place furadon 3G 10 g in perforated sachets in two inner most leaf axils for 2 times at 6 months intervals. Treat manure pits and other possible breeding sites with 0.01% carbaryl (50 % WP) on w/w basis. Treatment will have to be repeated every six months.

Red Palm Weevil: *Rhynchophorus ferrugineus*

The grubs cause damage inside the stem or crown by feeding on soft tissues and often cause severe damage especially when a large number of them bore into the soft, growing parts. In case of severe infestation the inside portion of trunk is completely eaten and become full of rotting fibers.

Control: Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem in order to prevent successful inward movement of the grubs through the cut end. In attacked palms, observe for the bore- holes and seal them except the top most one. Through the top most hole, pour 1% carbaryl (20gm/lt) or 0.2% trichlorphon @ one litre per palm using a funnel. Then plug this hole also. Setting up of attractant traps (mud pots) containing sugarcane molasses 2½ kg or toddy 2½ litres (or pineapple or sugarcane activated with yeast or molasses) + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils in large numbers. Incorporate any of the insecticide to each trap to kill the weevils trapped.

Coconut Eriophyid: *Aceria guerreronis*

Pest population occurs round the year but population maximum during June – Sep coinciding with the onset of monsoon.The earliest symptom on 2-3 month old buttons is pale yellow triangular patches seen below the perianth.Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk.In severe cases, the nuts are malformed with cracks and hardened husk.

Control: Spray with Round 1: Azadirachtin 1% (5 ml in one lit. of water),Round 2: Neem oil + Teepol (30 ml in one lit. of water),Triazophos 40 EC 5 ml/lit or monocrotophos 36 WSC @ 2 ml / lit or carbosulfan 25 EC 2 ml/ lit in alternation with neem azal 1% 5ml/lit as spot application.Neem cake application @ 5 kg per palm per year .

Diseases:

Basal stem end rot/ ganoderma wilt: *Ganoderma lucidem and Ganoderma applanatum*

Initial symptoms of Thanjore wilt (Ganoderma wilt) start with withering, yellowing and drooping of the outer whorl of leaves.Ganoderma appears at the base of the trunk. Ultimately the palm dies off.

Control: Remove and destroy all affected palms.Green manure crops must be raised and ploughed at the time of flowering.Apply FYM 50kg + neem cake 5 Kg once in 6 months along with fertilizers.Isolation of trench around the tree, 4 feet away from the base of the trunk. Apply Sulphur dust inside the trench.The bleeding patches in the stem may be chiseled and protected with tridemorph (5% calxin) and subsequently with hot coal tar.Trunk injection / root feeding with Calixin 3 ml/tree.Fortylitres of 1% Bordeaux mixture should be applied as soil drench around the trunk in a radius of 1.5m

BUD ROT: ***Phytophthora palmivora***

Palms of all age are liable to be attacked but normally young palms are more susceptible, particularly during monsoon when the temperature is low and humidity is very high. In seedlings, the spear leaf turns pale and comes off with a gentle pull. The earlier symptom is the yellowing of one or two younger leaves. Black spots appear on spindle leaves. Basal tissues of the leaf rot quickly and can be easily separated from the crown. In the later stages the spindle withers and drops down

Control: Provide adequate drainage in gardens. Adopt proper spacing and avoid overcrowding in bud rot prone gardens. Remove all the affected tissue of the crown region and crown drenching with Copper oxychloride 0.25%. (Apply Bordeaux paste and protect it from rain till normal shoot emerges. (Dissolve 100 gm of copper sulphate and 100 gm of quick lime each in 500ml. water separately and mix to form 1 litre of Bordeaux paste).The infected tissues from the crown region should be removed and dressed with Bordeaux paste sprayed with 1% Bordeaux mixture as pre-monsoon spray (May and September).Spray with Copper oxychloride 0.25% after the onset of Monsoon.

Lecture 25: Cashew nut

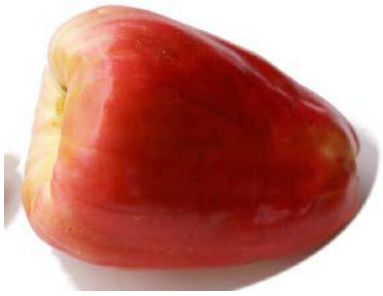
Scientific Name : *Anacardium occidentale* L.
Family :Anacardiaceae

Origin: Tropical America mainly Brazil .

Plant description: The cashew tree is a low spreading, evergreen tree with a very prominent tap root. The leaves are alternative, simple, glabrous, obovate, round and pinnately veined. The inflorescence is an indeterminate panicle of polygamo-monoecious type i.e. flowers are either bisexual or staminate but both occur intermixed in the same inflorescence Flowering appears in 2-3 distinct phases starting from November to February.1st phase: 19-100% male flower, 2nd phase: 0-60% male flower and 0-20% hermaphrodite (the most productive phase) and 3rd: 0-67% male flower. Anthesis takes place at 9am to 3.0pm, and pollination by flies, bees,wind,butterfly.

Cashew Bunch

Flowers



Pseudo Fruit (Cashew Apple)

Cashew nut

Area & Production: Introduced in Malabar coast of India in 16th Century to cover the bare soil for soil conservation but got commercial importance in 1920. India, Brazil , Kenya are the leading producer. Total annual production in India is 7.5 lakh ton .Maharashtra is the leading produces followed by Andhra Pradesh and Odisha. India produces only 40 percent of the world production of cashew nuts, it meets 90 percent of the world export of cashew kernels. The export

earnings from cashew constitutes about 2 percent of the total foreign earning from agricultural produce.

Importance and uses: Cashew apple is fleshy peduncle is juicy, sweet, astringent in taste when ripe. Rich in vit. C have 1015 -12.5 5 sugar and 0.35 % malleic acid. It is used to make a alcoholic beverages in Goa called ***Fenni***. Shell contains natural phenolic content called CNSL (Cashew Nut Shell liquid) which is used in polymer industry for warnish, paint etc. Cashew kernel testa is rich source of tannin. Its kernel is rich in protein, unsaturated fats, Ca, O, Fe and Vit .Cashew protein is rich in essential amino acids.It provides abot 600 cal/kg.

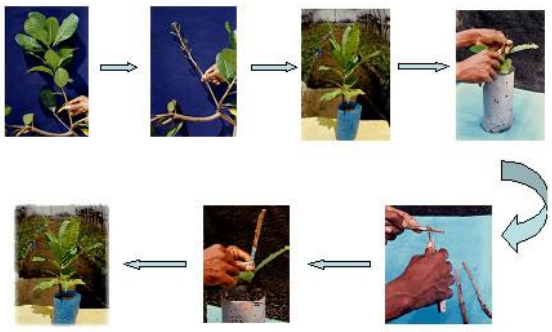
Fruit set: less than 10 % of hermaphrodite flowers causing low yield in cashew. It takes about 60 days to mature after fertilization.

Climate &Soil : Plains as well as hill slopes upto 600 - 700 feet elevation are suitable. It can grow well in places receiving rainfall from 50 cm to 250cm and tolerates a temperature range of 25°-49°c .It requires a bright weather and does not tolerate excessive shade. Cashew is cultivated on a wide variety of soils in India like laterite, red and coastal sandy soil. To a limited extent, it is also grown on black soils. It can be also grown in hill slopes in virgin organic matter rich soils. They do not prefer water logged or saline soils.

Variety /Clones

Tamil Nadu	Vridhachalam-1,Vridhachalam-2,Vridhachalam-3,VRI 4,VRI (CW) H1
Kerala Varieties	Akshaya (H-7-6),Amrutha (H-1597),Anagha (H-8-1),Anakkayam-1 (BLA-139-1),Dhana (H-1608),Dharasree (H-3-17), K-22-1,Kanaka (H-1598),Madakkathara -1 (BLA-39-4),Madakkathara-2(NDR-2-1),Priyanka (H-1591),Sulabha (K-10-2)
Andhra Pradesh Varieties	BPP-1,BPP-2,BPP-3,BPP-4,BPP-5,BPP-6,BPP-8(H2/16)
Karnataka Varieties	Chintamani-1,NRCC-1,NRCC-2,Ullal-1,Ullal-2,Ullal-3,Ullal-4,UN-50
Maharastra	Vengurla-1,Vengurla-2,Vengurla-3,Vengurla-4,Vengurla-5,Vengurla-6,Vengurla-7
Goa	Goa-1
Orissa	Bhubaneswar-1
West Bengal	Jhargram-1

Propagation: Mainly propagated by soft wood grafting, air layering and epicotyls grafting.



Softwood grafting

Time of planting: June – December is optimum for cultivation.

Planting Method: Planting distance: 7mX7m or 8mX8m About 200 plants/ha can be planted. For High Density Planting :Spacing of 5 x 4 m accommodating 500 plants per hectare is recommended prune the interlocking branches during the July-August to maintain the frame. Pits of 45 cm x 45 cm x 45 cm size are dug and filled up with a mixture of soil + 10 kg FYM + one kg neem cake.

Training & Pruning: Develop the trunk to a height of 1 m by removing low lying branches. The dried twigs and branches should be removed every year. Old and senile cashew orchards with poor yielder are cut down leaving a stump of 1 – 3 m height from the ground level. The emerging new sprouts are used as rootstock for epicotyl grafting. Suitable scions are collected and grafted on to the new sprouts. Flowers opening before the 3yrs should be removed (Deblossoming).

Fertilization:

Manures and fertilizers	I year old	II year old	III year old	IV year old	V year onwards
FYM or compost (kg)	10	20	20	30	50
N (g)	70	140	210	280	500
P (g)	40	80	120	160	200
K (g)	60	120	180	240	300

Apply in two split: Pre monsoon and post monsoon

Harvesting and yield: It starts flowering and fruiting after 3 years. Commercial yield starts after 10 yrs. and continue up to further 20 years. Yield up to 3-5 years is 3 kg nuts/plant,6-10 yrs: 6-8 kg nuts/plant, after 10-12 yrs 8-12 kg nuts/plant and 12 yrs onwards15 kg nuts/plant.

Processing: Steps in processing are:

Fruits harvested ⟹ Apples are removed ⟹ Nuts are sun dried for 2-3 days to reduce the moisture up to 9 % (raw nut) ⟹ Roasting (to make the shell brittle to separate the shell from krnel , (Steam roasting the most common method) ⟹ Shelling (Produces shell oil that is highly corrosive and Shell for CNSL) ⟹ Drying mostly

⟹

⟹

⟹

by broma dryer Peeling to remove testa Nuts separated grading packing

Specification for cashew kernels

Grade designation	Number of kernels per lb	Grade designation	Number of kernels per lb
W 180	375 to 395	W 320	660 to 705
W 210	440 to 465	W 400	770 to 880
W 240	485 to 530	W 450	880 to 990
W 280	575 to 620	W 500	990 to 1100

By products of cashew

After the processing of the shell and other left outs are used making some other products. The major bye products of cashew processing are:

1. Cashew Nut Shell Liquid 2. Shell charcoal

1. Cashew Nut shell liquid (CNSL)

The pericarp of the nut consists of a coriacious epicarp, spongy mesocarp and stony endocarp. The kernel covered with testa membrane is contained in a shell 1/8 inch thick. The mesocarp consists of a honeycomb network of cells containing a viscous liquid called cashew nut shell liquid (CSNL), which provides a natural protection to the kernel against insects. CSNL is a valuable raw material for a number of polymer based industries like paints and varnishes, resins, industrial and decorative laminates, brake linings and rubber compounding resins. CNSL is traditionally obtained as a by product during the isolation of kernel. The major constituent of shell oil is cardanol and anacardic acid of which cardanol is separately extracted and used in many industries. The shell oil was used as a preservative for boats and nets and to protect wood from termites. It is now largely exported and used in the manufacture of plastics, indelible inks, water proofing composition and other industrial products.

Extraction of CNSL

The extraction of CNSL involves various methods viz. hot oil bath, expellers, kiln method, solvent extraction etc, the most common method being hot oil bath. In this method the raw nuts are passed through a bath of CNSL itself by which the CNSL is extracted. This method extracts only 50% of liquid contained in nuts. Then through expellers about 90% of liquid can be extracted.

2. Cashew shell charcoal

The remains of shell after the extraction of CSNL is called shell charcoal. This is used as a fuel. The shell charcoal is used in processing of cashew for drying after shelling.

Plant protection

Pests

Stem borer: is also a dangerous pest and kill the entire plant. It is mostly seen in neglected gardens. Collection and destruction of affected shoots and swabbing the bark of exposed roots and shoots with Carbaryl 50 WP 2 g/lit. Twice a year before the onset of South West Monsoon (March – April) and after cessation of monsoon (November) painting of coal tar + kerosene mixture (1:2) or swabbing with a suspension of Carbaryl 50 WP (4 g/lit) can be done up to one metre length in the exposed trunk region after shaving the bark or swab the tree trunk with neem oil 5% thrice during January-February, May-June, and September-October.

Tea mosquito bug (*Helopeltis antonii* S.) : It can cause yield reduction to the tune of 30-40 per cent damaging tender shoots, inflorescence and immature nuts at various stages of development. It attacks the tree in all the seasons during flushing, flowering and fruit setting period but the peak period of infestation is from October to March. To control ,spray application of phosalone 35 EC@ 2.0 ml, followed by carbaryl 50WP @ 2g/l and monocrotophos @ 2ml/l at vegetative flush stage, panicle initiation stage and nut formation stage respectively

Shoot caterpillars (***Placaederus ferrugineus* L.)**:Shoot caterpillar can be controlled by spraying Profemophos 50 EC @ 2 ml/lit.

Diseases

Die back or Pink disease: Prune the affected shoots just below the affected portion and apply Bordeaux paste. Spray 1 % Bordeaux mixture or any copper fungicide like Blitox or Fytolan 0.25 % twice i.e. in May - June and again in October as a prophylactic measure.

Anthracnose:1.Remove the affected portions of plant/branches
2. Spray 1 % of Bordeaux mixture + Ferroussulphate at the time of flush initiation.

Lecture 26: Areca Nut

Scientific Name : **(*Areca catechu* L.)**

Family **: Palmae**

Origin: Malayan Archipelago, Philippines and other East Indian Islands

Distribution : India, China, Bangladesh, Indonesia and Myanmar are the major areca nut growing countries in the world are. India leads the world in production followed by China and Bangladesh. Areca nut is cultivated in India in an area of 3.13 lakh hectares with a production of 3.79 lakh tonnes. It is grown primarily in Karnataka, Kerala, Assam, Maharashtra and West Bengal.

Uses : Arecanut is commonly known as betel nut or supari. It is cultivated primarily for its kernel i.e a common chewing nut obtained from the fruit which is chewed in its tender, ripe or processed form .The seed contains alkaloids such as arecaidine and arecoline, which, when chewed, are intoxicating and slightly addictive. The seed also contains condensed tannins (procyanidins) called arecatannins which are carcinogenic. The areca palm is also used as an interior landscaping species. It is often used in large indoor areas such as malls and hotels.

Plant description: Plants have large, evergreen leaves that are either palmately ('fan-leaved') or pinnately ('feather-leaved') compound and spirally arranged at the top of the stem. The leaves have a tubular sheath at the base that usually splits open on one side at maturity. The inflorescence is a spadix or spike surrounded by one or more bracts or spathes that become woody at maturity. The flowers are generally small and white, radially symmetric, and can be either uni- or bisexual. : The fruit is usually a single-seeded drupe (sometimes berry-like) but some genera (e.g. Salacca) may contain two or more seeds in each fruit . It is a cross pollinated crop and fruit set normally varies form 12.0 to 40.0 percent and the time taken from full bloom to maturity of the fruit ranges from 35 to 47 weeks.

Varieties: Mangala, Sumangala, Subamangala, Mohitnagar, Srimangala, Samruthi (Andaman), Hirehalli dwarf, VTLAH 1, 2 and Thirthahalli dwarf. SAS-1, Srivardhan

Soil and climate: It can be grown on wide range of soil**.** It thrives best in well drained laterite, red loam and alluvial soils .The soil should be deep and well drained. Adequate protection from exposure to South-Western sun is essential to avoid sun-scorching. . It is sensitive to moisture deficit and should be grown where adequate water facilities are available.Grows in a wide range of temperature range, the ideal is from 10^{0} C to a maximum of 40^{0}C. Altitudeupto 1000 m above Msl. Rainfall – 750 – 4500 mm.

Propagation: By seed

Nursery raising: Mother palm should be more than ten years old with early bearing nature and with good fruit set. Fully ripe nuts weighing more than 35g should be selected from mother palms. Selected seed nuts are sown 5cm apart in sand beds of 1.5m width and convenient length with their stalk ends pointing upwards. Beds are to be watered daily. Germination commences in about 40 days after sowing.

After the sprouts have produced two to three leaves, they are transplanted to a polythene bag 30 x 10 cm filled with forest soil and are allowed to grow for 12 to 18 months under partial shade. The seedlings can also be transplanted in secondary nursery beds with a spacing of 30 cm on either side. Watering should be done regularly. Three month old sprout can be tran planted in secondary nursery beds of 1.5m width and convenient length. Partial shade to the seedlings can also be provided during summer by pandal or growing banana. Care should be taken to drain the nursery beds during the monsoon and to irrigate them during the dry months. Weeding and mulching should be done periodically. Seed nuts can also be sown in polythene bags (25 X 15 cm size ,150 gauge) after filling the bags with potting mixture containing 7 parts of loam or top soil, 3 parts of dried and powdered farm yard manure and 2 parts of sand.

Planting: The planting is done during May- June with the onset of monsoon. Arecanut palms need adequate protection from exposure to the South Western sun as they are susceptible to sun-scorch. Dwarf and compact seedlings with more number of leaves should be selected. Seedlings of 1 - 2 years age are planted in pits of about 90 cm x 90 cm x 90 cm at a spacing of 2.75 m either way and covered with soil to the collar level and pressed around. Provide shade during summer months. Growing Banana or other crops in advance may also provide shade.
When arecanut is planted as a mixed crop with other crops, a spacing of 3.3m x 3.3m is optimum.

Manures and Fertilizers:

A fertilizer dose of 100g N, 40g P20S and 140g $K_2$0 (220g of urea; 200g of rock phosphate and 230 g of muriate of potash) per palm per year is recommended along with 12kg of green leaf and 12kg compost or farm yard manure. For seedlings, 1/3 of the recommended dose of chemical fertilizers is sufficient during Ine first year; 2/3 during the second year and ful1 dose from third year onwards.

Inter culturing:Weeding is done twice or thrice a year by spade digging. Wherever the land is sloppy, terracing has to be done to prevent soil erosion . A light digging may be required when the monsoon ends to break up any crust formed at the soil surface and also to uproot weeds. Weeding should be done periodically to keep the garden clean.

Inter cropping: Cocoa, black pepper, coffee, vanilla, cinnamon, clove and citrusBanana, pepper and cocoa can be grown in inter-spaces as mixed crop in coastal Karnataka and Kerala. Acid lime and betelvine are suggested in West Bengal and Maidan parts of Kamataka .

Harvesting and processing : The bearing starts after 5 years of planting. Nuts are harvested when they are three quarters ripe. The number of harvests will vary from three to five in one year depending upon the season and place of cultivation. The stage of harvesting also depends on the type of produce to be prepared for the market

Yield:

An average of about 1250 kg/ha can be obtained.

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1. Dried ripe nuts/Chali/Kottapak

The most popular trade type of arecanut is the dried, whole nut known as chali or kottapak. Fully ripe, nine months old fruits having yellow to orange red colour is the best suited for the above purpose. Ripe fruits are dried in the sun for 35 to 40 days on dry leveled ground. For drying and dehusking, sometimes fruits are cut longitudinally into halves and sun dried for about 10 days, then the kernels is scooped out and given a final drying.

2. Kalipak

Another form of processing is by making kalipak. The nuts of 6 to 7 months maturity with dark green colour are dehusked, cut into pieces and boiled with water of dilute extract from previous boiling; a kalli coating is given and dried finally. Kali is the concentrated extract obtained from boiling 3 to 4 batches of Kalipak.

3. Scented suparis

There are many varieties of scented suparis. Dried arecanuts broken into bits, blended with flavour mixture and packed. Formerly the bits were roasted in ghee or oil, but it is almost fully given up nowadays, owing to development of rancidity. The flavouring of supari varies with region and is a closely guarded secret.

Plant protection:

Pest:

Mites: (red and white) *(Raoiella indica*a nd *Oligonychus indi CLIS* Hirst.). Mites can be controlled by spraying Dicofol 18.5 EC at 2.5 ml/lit.

Spindle bug:*Carvalhoiaarecae)* Can be controlled by Drenching spray with Methyl parathion 1.3 D @ 2.5 g/lit of water or Dimethoate @ 1.5 ml/lit.

Tender nut drop *(Halyomorpha marmoreal :*

Inflorescence caterpillars:*Tirathahamundella)* Dust Methyl parathion 20 EC 2 ml/lit or WP @ 2.5 g in one litre of water

Disease:

KolerogaBud rot or Mahali disease*(Phytophthara meadii)***:**Infected tissues of the bud should be scooped off and treated with 10 % Bordeaux paste. Destruction and removal of seed palms and also bunches affected by Mahali and drenching crowns of surrounding healthy palms with 1 % Bordeaux mixture would help in minimizing the incidence of the disease.

Footrot or Anabe :*Ganoderma lucidum):*

Affected palms have to be isolated by digging trenches all round. The severely affected palms should be cut and destroyed. The stumps should be pulled out by digging and the drainage improved.Soil application of neem cake @ 2 kg / palm / year followed by root feeding with 125 ml of 1.5 % (15 ml/litre of water) Tridemorph at 3 months interval or Soil drenching of Bordeaux mixture (1%).

Nut crack : Spray Borax 2 g/lit with proper water management.

Lecture 27: Coffee

There are two species of coffee that are cultivated commercially

Coffea arabica (Arabica coffee)

Self-fertile allotetraploid (2n=2X= 44),Small bushy plant, profuse branching with dark green leaves and white flowers, takes 8-9 months for berry development .

C. canaphora (Robusta coffee) : Cross ;pollinated Diploid (2n= 22) ,Robust plant, large leaves, takes 10-11 months for berry development.

Family: Rubiaceae

Origin :

Arabica coffee: Originated from Ethiopia, from a place called Caffa. The word coffee is derived from the place called caffa. Here it occurs naturally in the forest between 1,400 to 1,800 feet elevation.

Robusta coffee = Believed to be originated from Central Africa (Congo and Zaire region)

Introduction of coffee to India

Arabica coffee: It was introduced in 1670 by Muslim piligrim Baba Budan. He brought seven seeds from Yemen and cultivated in Chikmagalur, Karnataka. The original seeds he brought were probably Mokka seeds.

Robusta coffee: It was introduced from Indochina region at the close of 19th Century for planting in the estates of lower elevations

Distribution of coffee:

Coffee is susceptible to frost and hence, distribution is limited by temperature.

World: It is distributed between 25º N and 25º S. LCultivation is mainly in developing countries but consumption is largely in developed countries: Cultivated in about 80 countries mostly of developing world. Total area under coffee is 11. 6 million ha. Brazil is the leading country with 21.2 percent area of total coffee area in world. Area under coffee in India is 2.60 per cent of world acreage (8th position in the world) India accounts for 3 per cent of world coffee

production. In India area under *arabica* coffee is nearly 49 per cent while that of *robusta* coffee is nearly 51 per cent of total coffee area.

Production and productivity of coffee in India:

Productivity of Arabica coffee = 815 kg/ha

Productivity of Robusta coffee = 1065 kg/ha

Average productivity = 946 kg/ha

Important differences between arabica and robusta coffee

Sl. No.	**Characters**	**Arabica coffee (C. arabica)**	**Robusta coffee (C. *canephora)***
1	Ploidy	Tetraploid (2n =44)	Diploid (2n =22)
2	Adoptability	Higher elevations (1000 to 1500m)	Comparatively lower elevations (500 to 1000m)
3	Plant stature	A small tree, shrub or a bush under training.	Bigger tree than Arabica
4	Number of days for blossoming after the receipt of blossom showers	9 to 10 days	7 days
5	Berries per node	10 to 12 per node but bigger	40 to 60 per node but smaller
6	Fruit development period	8 to 9 months	10 to 11 months
7	Root system	Small but deep	Large but shallow
8	Pollination and fertilization	Self fertile and self pollination	Self sterile and cross

Coffee is a short day plant and is South India, flower initiation takes place between September to March. The flower buds grow into a definite size under fairly cold winter conditions and undergo a period of dormancy due to the onset of drought coupled with high temperature, long day and high light intensity conditions prevailing in dry months (November to march) depending upon the places. There is practically no vegetative growth during these dry months. Immediately after the blossom showers, growth changes are conspicuous in flower buds on the third day following rains due to the moistening of the flower buds, soil wetness and low temperature that follows immediately after rain. This causes the plants to blossom within 7 to 10 days. This imposed dormancy is a necessary event, as it enable single harvest , otherwise, coffee will be blooming through out the year resulting. in staggered harvesting concomitant with increased cost of picking , etc. The fruit is a drupe and normally contains two seeds. Abortion of one ovule due to non- fertilization leads to the formation of a single seeded fruit, called pea berry .Sometimes , 3 or more seeds may be present due to trilocular ovaries or false polyembryony and is often called triangular seeds. Occasionally, formation of more than one ovule per locule is seen and such seeds are known as elephant bean.

Climate &Soil :Grown under shade forest to create suitable micro climate. Well distributed rain with good shade.Arabica : Suitable for high land process superior quality, susceptible to diseases & pests. Robusta : Suitable for low lAnd& tolerant to diseases & Pests.Soil should be deep, friable, open textured rich in plant nutrients with plenty of humus and of slightly acidic nature (pH – 4.5 to 6.5)

Varieties Variety	**Parentage**	**Special Chracters**
S.795 (Sln. 3)	S.288 x Kent	Resistant to leaf rust race 1 and 11
Sln.7 (San Ramon hybrids)	San Ramon short internode arabica spotted in Costa Rica	Dwarf in nature, but segregates to tall by 30%
Sln. 8 (Hibrido-de-timor)	A spontaneous hybrid of robusta– arabica, spotted in portugesetimor island	Highest vertical resistant to leaf rust
Sln.9	Sln. 8 x Tafarikela	Drought hardy, suitable to different coffee zones
Sln.10 (Catura crosses)	Catura x S.795 or Sln.8	Drought hardy, suitable to different coffee zones

Variety /Clones : Arabica: 12 selections for leaf rust resistance and productivity , quality.S. 795 :Deivative of cross between S.288 &Kents occupying 70 % of the Arabica area., sln. 5A, Sln. 5B, Sln. 6, Sln. 9, Sln. 12, Sln. 274, Sln. 270,
C XR : Cross between *C.congensis* X *C. canephora*

Sowing

Pre-sowing seed treatment wiith *Azospirillum* and *Phosphobacterium* can be done.Seeds are sown in December - January in the bed 1.5 - 2.5 cm apart with the flat side down wards in regular rows. Then they are covered with a thin layer of fine soil and a layer of paddy straw.Water the beds daily and protect from direct sunlight by an over headpandal. Seeds germinate in about 45 days after which they are transplanted to a secondary nursery beds for raising ball or Bag nursery

Propagation :By seed

Arabica coffee: maintained due to self pollination & self compatible.

Preparation of seeds

Healthy and well developed fully ripe berries are harvested from specially identified plants for use as seed bearers. After discarding the floats, the sound fruits are depulped, sieved and mixed with sieved wood ash and dried in shade. The seed is then graded to remove all cut, triangular and elephant beans. Prior to planting,

Nursery practices

A land with light loamy soil of good drainage with high organic matter content with water and shade facilities is selected.Raised beds of 15 cm height, 1m width and at convenient length is made and 30 - 40 kg of well rotten compost, 2 kg of finely sieved agricultural lime and 400 g of rock phosphate is added to a bed of 1 x 6 m size. In heavy soils, it is necessary to add coarse sand for drainage and aeration.

Sowing

Pre-sowing seed treatment wiith *Azospirillum* and *Phosphobacterium* can be done.Seeds are sown in December - January in the bed 1.5 - 2.5 cm apart with the flat side down wards in regular rows. Then they are covered with a thin layer of fine soil and a layer of paddy straw.Water the beds daily and protect from direct sunlight by an over headpandal. Seeds germinate in about 45 days after which they are transplanted to a secondary nursery beds for raising ball or Bag nursery

Robusta : By cutting

Time of planting:Seed sowing in Dec. Jan. at a distance of 2.5-3.0 cm. Seed germination in 45 days. Ideal stage of planting: Seedling with 5-6 pairs of leaves in about 6 months

Planting Method:

Preparation of field

Selective felling may be done while retaining a number of desirable shade trees. Terracing should be done in deep slopy areas. After the summer showers, pits of 45 cm x 45 cm x 45 cm are dug at 1.25 - 2.5 m apart. The pits are left open for weathering and then filled and heaped for planting. At the time of filling, apply 500 g of rock phosphate per pit along with top soil. Planting is done along the contour in slopy areas.

Spacing and planting:

Sl. No	**Type of Coffee (species)**	**Variety**	**Spacing**
1	Arabica	Talls	6’ x 6’ or 7’ x 6’ or 7’ x 7’
2	Arabica	Dwarfs (Cauvery / Sanramon)	5’ x 5’
3	Robusta	Talls (S-274 and old robustas) S-1 R and S-2 R	10’ x10’ or 12’ x 12’
4	Robusta	C x R (S-3R)	8’ x 8’
Other robustas viz., Old robusta and S-274		10’ x10’ or 12’ x 12’	

Planting Distance: Arabica: 6" X6" or 7'X7'

Robusta: 10' X10'

CXR: 8'X8' or 9'X9'

Training & Pruning: Single stem system: Topping is done at 75 cm ht. in Arabica and 110-120 cm in robusta to restrict vertical growth.

Multiple stem: Not practices in India.

Pruning & Thinning is done to balance the vegetative and reproductive buds. Desuckring of orthotropic branches is also done; nipping is done to remove primary branches to encourage secondary and tertiary branches.

PRUNING IN COFFEE

Coffee bean crop on second year wood and hence, require regular pruning. Purpose/Principles of pruning in coffee is to encourage new growth **:**In coffee by pruning old unproductive wood is removed there by encouraging the growth of new branches. These new branches/growth would become next year cropping wood.

Shade and its management

Under the climatic conditions existing in India coffee is being cultivated under shade. It comprises of two canopies lower or temporary and upper or permanent. Dadap is used as a lower canopy shade in India. Next to dadap, silver oak is the most commonly used tree for temporary shade. The most popular permanent shade trees found in south India. *Albizzia lebbec, A.odoratissima, A.moluccana, Artocarpus integrifolia,* etc., Permanent shade trees are generally planted about 12 to 14 m apart. The most convenient time to regulate shade is after pruning and liming .

Nutrition Management

Maintaining optimum pH by liming is essential requirement for nutrition management in coffee. If proper pH is not maintained, the applied fertilizers will not be utilised by the plants effectively.The recommended dose of fertilizers should be applied in three splits (post-blossom, pre-monsoon, post-monsoon) by adopting drip circle method. In slopy areas, the fertilizers should be applied in the upper half of the drip circle.

Age of plant	**(Dose per plant in grams)**								
	Pre blossom (March)			Post blossom (May)			Post Monsoon (October)		
	N	**P2O5**	**K2O**	**N**	**P2O5**	**K2O**	**N**	**P2O5**	**K2O**
I Year 8	**8**	**5**	**8**	**8**	**5**	**8**	**8**	**5**	**8**

II & III Year	**10**	**8**	**10**	**10**	**8**	**10**	**10**	**8**	**10**
IV Year	**13**	**10**	**13**	**13**	**10**	**13**	**13**	**10**	**13**
V Year & Onwards	**24**	**15**	**24**	**24**	**15**	**24**	**24**	**15**	**24**

water at 15 days interval during dry spell.

Harvesting & PHM:

Harvesting

Coffee fruits should be picked as and when they become ripe to get better quality. Arabica comes for harvesting earlier since they take 8-9 months for fruit development from flowering while robusta takes 10-11 months. Picking is done by hand. The first picking consists of selective picking of ripe berries often seen in the outer portion of the node and is called fly picking. Thereafter, there will be 4-6 main pickings at 10-15 days intervals and final harvest. Stripping consists of picking of still remaining green berries on the plant.

Harvesting Time:Arabica: Nov-Jan
Robusta: Dec.- Feb. Manual harvesting is practiced.
Avg. yield: Robusta: 1000-1200 kg/ha (unirrigated)
2000-5000 kg/ha (irrigated)

Processing of Coffee

Coffee is processed in two ways a) wet processing to prepare plantation or parchment coffee and b) dry method by which cherry coffee is prepared

Parchment Coffee; Mostly from arabica

Ideally mature fruits→ pulping on the day of harvest to avoid fermentation → sieving of pulped parchment→ demuscillaging→ allowed to fermentation (24-36 hrs for Arabica 48-72 hrs for robusta) → alkali treatment with 10m % caustic soda) → now beand are brittle & rough→ soaking in water for 12-24 hrs→ washing →sun drying→continuos heaping & drying for 7-8 days to reduce the moisture . → packing& storage

Cherry coffee: mostly from robusta

Collection of ripe fruit → sorting of green, over ripe & unripe fruits → drying for 10-12 days till beans produces ratteling sound

Pest Management

Coffee berry borer (*Hypothenemus hampei*)

Coffee berry borer is the most serious pest of coffee world over. The female beetle bores into the berries through the navel region and makes tunnels in the hard bean and lays about 15 eggs. The larvae feed on the beans, making small tunnels. A typical pinhole at the tip of the berries indicates the presence of the pest, and it damages young as well as ripe berries. In case of severe infestation, 30 to 80% berries may be affected resulting in heavy crop loss. The coffee berry borer can be controlled by the following methods.

- Carry out timely and thorough harvest.
- Avoid gleanings as far as possible.
- Pick up and destroy the gleanings.
- Meticulously remove the leftover berries.
- Remove offseason berries to save main crop.
- Avoid excessive shade.
- Prune plants properly to facilitate better ventilation and illumination.
- Spray Quinalphos 25 EC @ 340 ml/200 lit or lamdacyhalothrin 5 EC 120 – 160 ml / 200 lit.
- While processing at the estate level dry coffee berries to the prescribed moisture level : Arabica / robusta parchment 10 %, Arabica cherry 10.5 % and robusta cherry 11.0

White stem borer

Plants show unhealthy symptoms like wilting and yellowing of leaves. The beetles are active and females lay eggs in the crevices on the main stem of coffee.

Control mearsure:

- Maintain/create optimum shade
- Borer infested plants should be thoroughly trace, uprooted during March and September, burnt to avoid economic loss during the subsequent years.
- Install pheromone traps @ 25 /ha, if the incidence is high.
- Remove the loose scaly bark on the main stem and thick primaries using coir glove or coconut husk.
- Pad with monocrotophos 36 WSC @ 5 ml by making a window in the stem at 5 cm x 5 cm and fill it with absorbant cotton dipped in insecticide solution and close it.

Disease Management

Leaf rust (*Hemileia vastatrix*)

This is an important disease causing economic loss particularly in arabica coffee. On the lower surface of the infected leaves, small pale yellowish spots appear early after the first rains in the season. These spots soon increase in size and number, and many such spots coalesce at severity causing premature defoliation. Severe defoliation leads to debilitation of the bushes and results in poor cropping in the succeeding seasons.

Control

Spray 0.5% Bordeaux mixture in February - March (Pre-bloom) followed by 0.03% Oxycarboxin in May - June (Pre-monsoon). Repeat in July - August (mid-monsoon) September - October (Post-monsoon) with any one of the above fungicides or Spray 0.5 % Bordeaux mixture during the month of June followed by 0.02 % Triadionefon during September and 0.5 % Bordeaux mixture during the month of December.

Black rot (*Koleroganoxia*)

A disease more in occurrence in endemic areas with heavy rainfall, saturated atmosphere with 95-100% RH, thick overhead shade, low over-hanging branches, sheltered from sunlight and wind in valleys or continuous mist during monsoon. The affected bushes have blackening and rotting of leaves, twig and developing berries. There will be defoliation and berry drop in the affected branches. The entire block affected looks totally debilitated with heavy damage to crop.

Control

Centering and handling of the bushes prior to the onset of monsoon and protecting endemic patches with spraying Bordeaux mixture 1%. If incidence is observed during the monsoon, remove the affected twigs and burn them. Spray with Bordeaux mixture 1% during break in the monsoon.

Lecture 28: Tea

Scientific Name: Camellia sinensis L O.Kuntze.

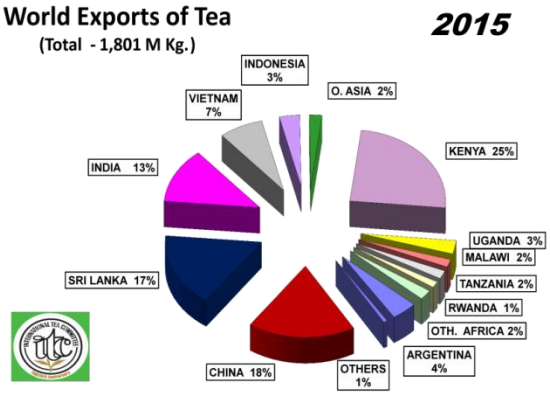
Family: Camelliaceae

Origin:
Chinese people were the first users of tea. The region from South East China (Szechwan-Yunnan) to Assam (India) has been reported as the centre of origin of the tea plant.

Tea is an aromatic beverage commonly prepared by pouring hot or boiling water over cured leaves .It is an evergreen shrub (bush) native to Asia. Tea originated in Southwest China, where it was used as a medicinal drink.It was popularized as a recreational drink during the Chinese Tang dynasty, and tea drinking spread to other East Asian countries. Portuguese priests and merchants introduced it to Europe during the 16th century. During the 17th century, drinking tea became fashionable among Britons, who started large-scale production and commercialization of the plant in India to bypass the Chinese monopoly.

World distribution: Major tea growing area in the world (Nearly 93 %) is in developing countries. Asia = 86 % of area and Africa =8 % of total area (during 1986) Asia: India, China and Sri Lanka are the main tea producing countries in the world. India produces nearly 30 % of world tea production followed by China (22 %) and Sri Lanka (8%).

India has around 563.98 thousand hectares of area under tea production, as per figures for December 2013. Tea production is led by Assam (304.40 thousand hectares), West Bengal (140.44 thousand hectares), Tamil Nadu (69.62 thousand hectares) and Kerala (35.01 thousand hectares). Production of tea reached 1,233.14 million kg in 2015-16. Around 1,008.56 million kg was produced in North India and 224.58 million kg was produced in South India .According to estimates, the tea industry is India's second largest employer. It employs over 3.5 million people across some 1,686 estates and 157,504 small holdings; most of them women.
The top export markets in volume terms for 2015-16 were Russian Federation (48.23 million kg), Iran (22.13 million kg) and Pakistan (19.37 million kg). In terms of value, the top export markets were Russian Federation (US$ 102.48 million), Iran (US$ 87.39 million) and UK (US$ 62.8 million). All varieties of tea are produced by India. While CTC accounts for around 89 per cent of the production, orthodox/green and instant tea account for the remaining 11 per cent.



Tea plantations were confined to Upper Assam only but later on, new areas such as lower Assam and Darjeeling were also opened up to tea cultivation, there were 35 tea plantations in Assam alone. Later on, tea cultivation started in Nilgiri Hills of Southern India, Tarai along the foothills of the Himalayas and in some area of Himachal Pradesh and Meghalaya.

India:

In India 80 % of the area is above 50 ha in size and most of them are in corporate sector (United body)

North India = Nearly 80 per cent of total area in India,

South India = Nearly 20 % of total area in India

Health Benefits of Tea:- Tea contains abundant antioxidants.It contains less caffeine compared to coffee. Tea may help in reducing risk of heart attack and stroke and improve immune system. As a beverage: Tea contains alkaloids called thein (2 to 5 %) which is a caffein aceus alkaloid relieving body fatigue. However, excessive tea drinking is harmful to our digestive systems. Polyphenols present in tea reduces blood cholesterol and cures hepatitis, hypertension, stone formation etc. (Heart attack is due to cholesterol + triglycerides which is a saturated fatty acid) . Medicinal properties: Black tea (a fully fermented tea) is anti ulceric and ant carcinogenic in nature.

Research Stations Board working on tea cultivation and in India

1. UPASI = United Planters Association of Southern India, UPASI Tea Research Institute, Nirar Dam B.P.O, Velparai – 642 127, Dist: Coimbatore, TN.
2. TES = Tea Experiment Station, Tocklai, Jorhat, Assam
3. **Tea Board**: Calcutta

There are mainly two species of tea used as beverage. These are **Assam tea** and **China tea.**

Different features of Assam tea and China tea.

Sl. No.	**Features**	**Assam tea (*Camellia sinensis* var *assamica)***	**China tea (*Camellia sinensis* var**
1	Stature	Tree	Stature

2	Branches and growth rate	Few robust branches and quick growing	Abundant branches and slow growing
3	Leaves	Large (15 to 20 cm long) and glossy and less serrated	Small (4 to 10 cm long), leathery and more serrated
4	Quality	Medium (better strength)	Good (Better flavor)
5	Yield	High yield	Low yield
6	Susceptibility to drought and frost	Susceptible	Hardy and resistant (Winger hardy)
7	Distribution	Countries near to equator viz., India, Sri Lanka, S.E. Assia, Central Africa etc	Cold countries and high altitude areas like Japan, N- Iran, S. Russia, or China *etc*
8	Economic life	Less (40 years)	More (Over 100 years)

Soil and climate:

Tea plantation requires a moderately humid and hot and climatic condition. Tea plantation thrives well in humid and hot weather condition. The optimum temperature range for tea plant growth is 20° to 27°C and temperatures above 35°C and below 10°C can damage the tea plants growth. **It** requires well distributed rainfall from 150 cm to 300 cm throughout the year. Tea is a shade loving plant and grows more vigorously when it planted along with shady tree areas. It thrives well in deep, well drained, friable loamy soils. Virgin forest soils that are rich in humus and iron are the best suited soils for tea plantations and large proportion of potash and phosphorus in the main soil gives special flavour to tea as is the case in Darjeeling. Water logging will damage the plants, so make sure there is easy way of draining the soil. Tea requires well drained soil with high amount of organic matter and pH 4.5 to 5.5.

Varieties

Pandian, Sundaram, Golconda, Jayaram, Evergreen, Athrey, Brookeland, BSS 1, BSS 2, BSS 3, BSS 4, BSS 5, Biclonal seed stocks and Grafts.

Planting: This is a very delicate operation and needs adequate planning and proper supervision. Correctly planted tea plants establish in the field quickly, grow vigorously and come into full bearing earlier.

Time of Tea Planting: Planting can be done in April-June and September-October or October-November with adequate irrigation. Periods of heavy rains should be avoided.

Only healthy plants 40 cm to 60 cm high with at least 12 good mature leaves and of pencil (0.5 cm) thickness (at collar) should be taken for planting in field. In general, 9 – 12 month old plants attain this stage. Sub-standard plants should be discarded. Before plants are removed from nursery, they should be hardened by gradual exposure to full sun.

Type of Tea planting: There are two types of planting:1) pit planting 2) trench planting

Nursery

The nursery soil should be well drained and deep loam in nature with pH of 4.5 to 4.8. The soil and sand used in the preparation of rooting medium should be tested for pH and nematode infestation.

Pre-treatment of rooting medium

Treating with Aluminium sulphate can reduce soil pH. For this purpose the nursery soil is formed into beds of one metre width and about 8 cm height and of a convenient length. Then the beds are drenched with 2% solution of Aluminium sulphate applied at 10 litres/2.5 sq.m of area. Over this another layer of soil of 8 cm height is spread and again drenched with equal quantity of water twice. Then the soil is allowed to dry and the pH is checked before use in the nursery.

Preparation of sleeves

Polythene sleeves of 150 or 200 gauge and 10 cm width and 30 - 45 cm length may be used. Drainage holes may be provided at the bottom. The lower 3/4 of the sleeves should be filled with 1:3 sand and soil mixture and the top 1/4 with 1:1 sand and soil mixture and staked in rows. Overhead shade is provided.

Preparation of cuttings: Cuttings are taken on April - May and August - September. Semi hard-wood cuttings are prepared with one leaf and an internode with a slanting cut at the bottom.

Hardening of the cuttings

Hardening of 4 - 6 months old young cuttings should be done by removing shade gradually in stages over a period of 4 - 6 weeks starting from a few hours exposure to sun every day initially and extending the time of exposure gradually.

Planting of cuttings

The sleeves are watered thoroughly and holes are made in the soil. The cuttings are inserted in the hole and the soil around is pressed firmly to avoid airspace followed by watering. Small polythene tents may be provided which maintain high humidity and regulate the temperature inside. Cuttings may take 10 - 12 weeks for rooting. After 90 days i.e. when all the cuttings have rooted, the polythene tent may be removed gradually over a period of 10 - 15 days.

Spacing: Plant population of tea bushes vary from 14 to 18 thousands per ha. Higher plant population showed adverse effect after 4 to 5 years. Spacing varies from region to region and variety to variety

1.5 m x 1.5 m or

1.5m x 0.75 m = 14000 plants per ha closer spacing gives quick covering
1.2 m x 0.75 m or

1.2 m x 0.60 m = accommodates more than 16,000 plants per ha

Methods of planting

Single Hedge System

In this method, the spacing adopted is 1.20 x 0.75 m accommodating 10,800 plants/ha.

Double Hedge System

In this method, the spacing adopted is 1.35 x 0.75 x 0.75 m accommodating 13,200 plants/ha.

Irrigation

Subsoil irrigation may be given for young tea seedlings during summer months

Manuring

Manuring should be done 2 months after planting. Phosphorous should be applied at 80 - 100 kg/ha as Rock phosphate once in a year by placement at 15 - 25 cm depth up to the first pruning and thereafter once in two years. N : K ratio 2 : 3 should be adapted for the first 3 years and a ratio 1 : 1 thereafter.

	Total weight kg/ha/annum		**No. of applications**	**Qty/plant (g)**	
	N	**K**		**Ammonium Sulphate**	**Urea**
I year	180	270	5	13	27
II year	240	360	6	23	15
III year	300	450	6	29	18
IV year onwards	300	300	6	33	19

Application of fertilizers should be done before the onset of monsoon. Fertilizers should be broadcast around the drip circle avoiding contact with the collar.

After cultivation

Training young tea

Centering

To induce more laterals, centering should be done 3 - 5 months after planting. The main leader stem should be cut, leaving 8 - 10 matured leaves.

Tipping
Tipping is done at a height of 35 cm from the second tipping at 60 cm from ground level.

Pruning
Pruning is done to maintain convenient height of bush and to remove dead and diseased branches.
Area to be pruned every year = $\frac{\text{Total extent of the garden}}{\text{Pruning cycle}}$
Pruning interval = (Elevation in feet / 1000) + 1
Pruning should be done in April - May or August - September.

Types of pruning
Rejuvenation pruning
The whole bush should be cut near the ground level less than 30 cm with a view to rejuvenate the bushes.

Hard pruning
Hard/ formation pruning of young tea is done at 30 to 45 cm (12" to 18") for proper spread of bushes.

Medium pruning
To check the bush growing to an inconvenient height this type of pruning is done in order to stimulate new wood and to maintain the foliage at lower levels less than 60 cm.

Light pruning
Pruning depends on the previous history of the bush raising the height of medium pruning by an inch or less to manageable heights for plucking (less than 65 cm).

Skiffing
This is the lightest of all pruning methods. A removal of only the top 5 - 8 cm new growth is done so as to obtain a uniform level of pruning surface (more than 65 cm).

Shade maintenance and management in tea plantation
Tea requires filtered light and if it is exposed to direct sun its growth is affected. Tea bushes with semi – erect leaves don‟t require shade as the **leaves are not overheated when exposed and allow more light penetration into the bush.** Hence, the tea bushes with semi-erect leaves have highest yield potential as against the types with horizontal leaves. Broad leaved bushes perform better under shade.

Permanent shade trees: Albizzia spp (A. odoratissima and A. *stipulate, A. procera, A. moluccana and A. chinensis. Albezzia lebbeck* , silver oak etc) *Dalbergia sericea, Dalbergia assamica, Derris robusta* etc.

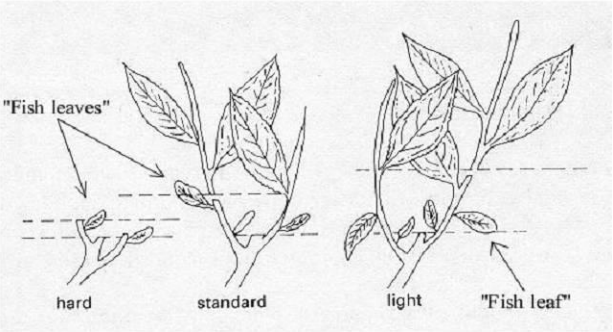
Temporary shade trees :: *Indigofera teysmani, Glyricidia sepium, Leucaena glauca, Erythrina spp.*(E. *subumbrans and E. lithosperma* i. e., dadap, silver oak (*Grevillea robusta).*

Plucking and harvesting:

Plucking commences when the tea bush is 3 years old. The plucking of extreme tip of the growing branch consists of an unopened bud together with two leaves is popularly known as "Two leaves and a bud", while fine plucking is anything less than this. In South India plucking continues throughout the year at weekly intervals during March - May and at intervals of 10 -14 days during the other months.

Rush period
During rush period harvesting is done at 7 to 10 days interval.

Lean period
During lean period harvesting is done at 10 – 15 days interval



Plucking Standard

Plucking in tea :It consists of collecting the newly grown vegetative shoots i.e., Harvesting in tea involves the regular removal of young shoots comprising an apical bud and 2 or 3 leaves, immediately below it. Tea crop consists of terminal buds and two or three leaves just below with the stalk. The retention of adequate maintenance foliage for the continued health and productivity of the bush is necessary.
Stage/Age of plucking: Plucking stage is attained when tea plant is of 3 to 4 yeas old. However, plucking stage under ideal management conditions is attained in 18 to 20 months stage.
Young leaves with more of **tannins and polyphenols** produces better quality tea than old leaves with less tannin content. Maximum yields (stable/economical stage of yield) are obtained in 6th or 7th year and there after the yields remains constant.

It is clear that, plucking of the terminal bud only or with terminal bud with I leaf gives excellent quality tea. Bud is usually plucked with I and II leaves. (i.e., **Best plucking is two leaves and a bud)**

Yield
Yield of made tea: 20 to 30 q per ha
20 q /ha = Low yield
20 – 30 q /ha = Medium yield
> 30 q/ha = high yield

Plant protection in tea:

Tea mosquito bug:

- Removal of alternate hosts like neem, cashew, guava in the surroundings
- When the infestation is lesser: Spraying of any one of the following:

1. Imidacloprid (0.6 ml/l)
2. Thiamethoxan (0.6 g /l)
3. Profenophos (2 ml/l).

Diseases of tea:
Blister blight :*Exobasidium vexans* (a fungal disease) :

It is commonly found fungi in South India, Darjeeling and Assam but moderate in Himachal Pradesh. This disease is endemic to the growing areas of Asia. It has been reported from almost all tea growing regions of India. The disease is more severe in South Indian plantations than that of North East Indian tea plantations
Blister blight can be controlled by adopting the following control measures.

Spray 210 g Copper oxychloride and Nickel chloride per ha at 5 days interval from June - September; 11 days intervals in October and November.

Spray Hexagonazole 200 ml + Copper oxychloride 210 g 5 days interval/ha

Processing of tea:
Manufacture of tea \ processing of tea
Tea contains 4.5 to 5 % Nitrogen compounds ¾ of which can be attributed to proteins and amino acids and ¼ to alkaloids. Chief alkaloids are thein , theobromine and theophyllomine.
Maximum caffeine content allowed is 3 %.
Basically there are three types of processing in tea (Based on the method of rolling in the preparation of black tea).
1) Orthodax method: Rolling operation is done in a series of rollers (i.e., based on the traditional method)
2) CTC (Crush, Tear and Curl) method: It has a CTC machine consisting of series of a pair of rollers adjusted to crush and tear leaves.

3) LTP (Laurie Tea Process (LTP): LTP is essentially a pulverizing machine. It carries many sets of beaters.

In the preparation of black tea, four principal operations are involved viz., (a) withering, (b) rolling, (c) fermenting, and (d) drying.

Manufacture black tea either by the CTC (Crush, Tear and Curl) or the orthodox method involves steps viz.,

1) Withering: Moisture content of leaves is reduced (to about 55 %) by drying in a trough receiving artificial air. Duration of drying varies from 12 to 18 hours.

2) Rolling: During rolling cells of leaves are broken to liberate sap containing polyphenol

oxydase (and enzyme). Rolling takes place for about 30 to 40 minutes.

3) Fermentation: Rolled tea material is spread on concrete floor or trays under high humidity and proper temperature to undergo fermentation. Properly fermented tea will attain **golden red colour** deciding the quality of tea. Thea flavins: and Thearufigens are compounds responsible for colour of tea.

4) Drying: Slow reduction in moisture content as to stop fermentation process. Moisture content is reduced to **about 4 per cent**. Duration of drying is for about 30 to 40 minutes.

5) Cleaning & grading: Remove stalky fibers and grade the tea by passing through different sized meshes.

Lecture 29: Rubber

Scientific Name: (*Heave brasilensis* Muel-Arg)
Fam: Euphporbiaceae

Origin: Amazon River basin of Southern America. This crop was introduced to South Asia through Kew garden in the U.K in the late 1970's. Now it is grown in tropical regions of Asia, Africa and America.

Distribution of rubber
Total rubber production in the world (1996) is 63.20 lakh tones. India ranks fifth and fourth in total area and production of natural rubber. In productivity India ranks first in the world. With an area of : 5.33 lakh ha and Production :5.44 lakh tones. India ranks first in the world with regards to the productivity of natural rubber i.e., 1,503 kg per ha. The major rubber growing stes are Kerala, Tamil Nadu ,Karnataka .These three states altogether accounts to 98 per cent of total produce of India.

Varieties
Tjir 1, PB 86, BD 5, BD 10, PR 17, GT 1, RRII 105, RRIM 600, PB 28/59, PB 217, PB 235, RRIM 703, RRII 5, PCK-1, 2 and PB 260

Soil and climate

It requires deep and lateritic fertile soil with an acidic pH of 4.5 to 6.0 and highly deficient in available phosphorous. Tropical climate with annual rainfall of 2000 – 4500 mm is suited for cultivation. Minimum and maximum temperature should be ranged from 25 to 34°C with 80 % relative humidity is ideal for cultivation. Regions prone to heavy winds should be avoided.

Season
June – July is optimum for cultivation

Method of propagation
Propagated by green budding, brown budding and crown budding.

Propagation:
Seed Propagation: For nursery planting seeds are germinated in shaded beds of friable soils, sand or coir dust. Germinated seeds are transplanted into shaded nurseries at spacing depending on the type of plant required. Seed germination will be completed in about 3 weeks. Seeds start germinating within 6 - 10 days of sowing.
Clonal seeds: Sexual progeny of budded clones is known as clonal seed. Seed garden progeny is probably a better name. As clonal seedlings are more variable than budded rubber their average yield is less. It is desirable to select for vigor in the nursery and in the field

and later for yield in the early years of bearing. Legitimate seeds may be produced by hand pollination between selected clones.

Budding: Popular method of vegetative propagation in rubber is by bud grafting using buds of selected mother trees. Nursery seedling can be bud grafted when they attain a girth of a pencil above the collar. Budded stocks are ready to be stumped about 4 weeks after budding. they are cut 10 - 15 cm above the bud patch and the stumps are pulled out and transplanted in the main field. Green budding with buds stripped from green shoots is also practiced.

Rubber is almost entirely propagated through bud grafting of modern high – yielding clones. Bud grafting is done on the seedlings when they are 2-8 months old using green or brown dormant bud patch collected from selected scion clones.

Depending on the colour and age of the buds two types of budding are recognized.

.Sl No.	Particulars	Brown budding	Green budding
1.	Age of stock	> 10 months old	2 to 8 months old vigourous seedlings
2	Maturity or age of scion or bud wood.	One year	6 to 8 weeks
3	Colour of bud wood	Brown and buds are in axils of fallen leaves.	Green and buds are in axils, when leaves are still attached and functi

Scion / bud wood = from bud shoots of 6 to 8 weeks growth.

Stock plant = Vigourous seedlings of about 2 to 8 months age.

Age of stock → Vigorous seedlings of 2-to 8 month's age with girth of about 2.5 cm and Brown bark up to a height of about 15 cm

Scion → Green buds taken from bud shoots of 6 – 8 week growth i.e. buds seen in the axil of scale leaves

Table: Clones developed by RRII for cultivation in South India

Sl. No	Name	Parents	Important traits
A.		Primary clones	
1	TJIR –1	-	Indonesian clone yield = 930 kg per ha per year
2	G.T –1	-	Indonesian clone, Yield =1360 kg per ha per year
3	Gl-1	-	Malaysian clone, Yield = 1130 kg per ha per year. Drought tolerant

Nursery: Bed size: 60-120 cm width and of convenient length.

Spacing: Seedling stumps – 23 x 23 cm, 30 x 30 cm and 34 x 20 cm

Budded stumps – 30 x 30 cm

Stump budding – 60 x 60 cm
Bud wood nursery – 60 x 90 cm or 60 x 120 cm.

Seedling Nursery:

Manuring: Basal -2.5 t/ha of FYM and 350kg/ha of Rock Phosphate.
1.5 – 2 months after planting –10:10:4:1.5 NPKMg mixture -2500 kg/ha.
Urea @550 kg /ha -3 to 3.5 months.

Planting: Pit size of 1 m3 are dug and filled up with top soil and compost

Planting material	**Spacing (m)**	**Population / ha**
Budded plants		
Hilly areas	6.7 X 3.4	445
Plains	4.9 X 4.9	420
Seedlings		
Hilly areas	6.1 X 3.0	539
Plains	4.6 X 4.6	479

In situ sowing: Germinated seeds are sown in situ in the pits. Healthy ones are retained and the others removed.

Manuring

For immature rubber trees at pre-tapping stage

Apply 12 kg of compost or FYM and 120 g of rock phosphate in each pit before planting. Apply 10:10:4:1.5 NPK andMg as per schedule given below:

Months after planting	**Period of application**	**Quantity per plant**	
		10:10:4	**12:12:6**
3	September/October	225 g	190 kg
9	April/May	445 g	380 kg
15	September/October	450 g	380 kg
21	April/May	450 g	480 kg
27	September/October	550 g	480 kg
33	April/May	550 g	380 kg
39	September/October	450 g	380 kg

Apply 400 kg of mixture/ha in 2 doses, once in April/May and another in September/October from the 5th year till the tree is ready for tapping.

Matured rubber trees under tapping

For matured rubber trees under tapping apply NPK 10:10:10 grade mixtures at the rate of 900 g/tree (300 kg/ha) every year in two split doses. Add 10 kg commercial Magnesium sulphate for every 100 kg of the above mixture if there is magnesium deficiency.

After cultivation

Growing of cover crops, incorporation of cover crops and weeding are important operations. *Puerariaphaseoloides*, *Calopagoniummuconoides*, *Centrosemapubescens* and*Desmodiumevalifolium* are common cover crops.

Tapping

S/2 d/2	(half spiral, alternate day for 6 months and rested for 3 months)	100% Intensity
S /2 d/2 6m /9	(half spiral, alternate day for 6 months and rested for 3 months)	67 intensity
S /2d/3	(half spiral, third day)	67 intensity
S/2 d/3 1m/2	(half spiral, daily for one month and rested for next month)	100% intensity
S /1 d/4	Full spiral, fourth day	100% intensity
V /2 d/2 12m/16	Half circumstances and cut alternate day for 12 months and rested for the next 4 months	75% intensity

Ethrel treatment

Ethrel is recommended to increase latex yield of trees. It is applied at 5% a.i. concentration with a brush below the tapping cut to a width of 5 cm after light scraping of the outer bark. The first application may be done after a drought period preferably after a few pre-monsoon showers and subsequent applications may be done in September and November. However, continuous application of Ethrel is not recommended for periods of more than 3 years at a stretch.

Tapping panel dryness (Brown bast)

Syndrome characterized by prolonged dripping of latex with the gradual decline in volume yield, pre coagulation of latex and partial or complete drying of tapping area (10-25 per cent).

Control

Reduce tapping intensity or give a tapping rest for 3 to 12 months.

Plant protection

Pests

Scale insect

When severe infestation is noticed, spray Organophosphorus insecticides like malathion 50 EC 2 ml/lit.

Mealy bug
Spray fish oil rosin-soap 25 g/lit. Release Austalian lady bird beetle, *Cryptolaemusmontrouzieri* @ 10/tree.

Termite (White ant)
Drench the soil at the base of affected plants with Chlorpyriphos 20 EC 2 ml/litre.

Cockchafer grub
Drench soil at the base of plants in the affected area with the solution of Chlorpyriphos 20 EC 2 ml/litre.

Diseases

Abnormal leaf fall
Prophylactic spraying on the foliage prior to the onset of South-West monsoon with, Bordeaux mixture 1% at 4000 - 5000 lit/ha using high volume sprayers.

Oil based Copper oxy chloride using low volume sprayer or through aerial application. Two rounds of spray using about 17 to 22 lit of fungicide oil mixture per ha per round (1:6 proportion) at 10 to 15 days interval (or) a single round of spray with about 30 - 37 lit of fungicide oil mixture per ha (1:5 proportion).

Secondary leaf fall
The control measures suggested for abnormal leaf fall will check this disease also.

Bird's eye spot
Repeated sprayings with Bordeaux mixture 1% or Mancozeb or Copper oxychloride 0.2%. Provide shade in nursery. Give balanced manuring to increase tree vigour.

Pink disease
Frequent tree to tree inspection should be done during July – September period for detecting the infected trees and application of Bordeaux paste in the early stages upto 30 cm above and below the affected region. In advanced cases apply Bordeaux paste and when it dries up scrape off the superficial mycelium and damaged bark and apply Bordeaux paste once again. Prune off and burn the dried up branches after disinfecting by Bordeaux spraying.

Dry rot, Stump rot, Collar rot or Charcoal rot
Clean up affected areas, by washing with Carbendazim (0.1%) solution. Scrape out the fructifications. Affected bark and wood show black lines. Wash the wound again with fungicide solution. When it dries up apply a wound dressing compound. Avoid accumulation of rubber at the base of the trees.

Brown root disease
Open up the root system. Completely killed and dried roots may be traced and pruned. Partially

affected and healthy roots washed withfungicideCarbendazim (0.1%) solution. When the fungicide dries up, a thin coating with a wound dressing compound may be given. Refill the soil and drench the base with fungicide solution.

Yield

Rubber yield steeply increases year by year, reaching a peak after 14 years of planting. In South India, the annual yield of rubber is 375 kg/ha from seedlings trees, whereas budded plants yield 800 - 1000 kg/ha.